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14. ABSTRACT
This TOP provides Laboratory Vibration Test Schedules (LVTS) for selected rotary wing aircraft. The LVTS presented in this TOP were developed from field measured data collected on the selected rotary wing platforms. The LVTS are designed to allow for the exposure of a test article to a flight vibration environment of a given rotary wing platform in a laboratory setting.

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U.S. ARMY TEST AND EVALUATION COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 01-2-603 12 June 2017
DTIC AD No.

ROTORCRAFT LABORATORY VIBRATION TEST SCHEDULES

1. SCOPE.

This Test Operations Procedure (TOP) provides Laboratory Vibration Test Schedules (LVTS) for selected rotary wing aircraft. The LVTS presented in this TOP were developed from field measured data collected on the selected rotary wing platforms. The LVTS are designed to allow for the exposure of a test article to a flight vibration environment of a given rotary wing platform in a laboratory setting.

1.1 Background.

a. The Department of Defense standard for Environmental Testing, which includes vibration testing, is Military Standard (MIL-STD)-810G with Change Notice 1 (CN1)[1**]. Method 514.7, addresses both secured cargo and installed equipment vibration environments induced by rotary wing aircraft in Categories 9 and 14 respectively.

b. MIL-STD-810G-CN1 strongly recommends tailoring laboratory vibration tests to the specific environmental interests as anticipated per the life-cycle environmental profile (LCEP). For example, consider the following vibration testing requirement: A component is to be installed on a CH-47F instrument panel and must first undergo vibration testing in a laboratory to demonstrate both structural endurance and functionality while being subjected to flight induced vibration. Ideally, a LVTS would be developed per the LCEP from flight vibration data acquired at the specific location on the CH-47F where the component is to be installed. This would allow for a high fidelity test in the laboratory. However, this approach, while superior from a technical standpoint, is often cost prohibitive. It is for this reason that MIL-STD-810G-CN1 provides default, region specific LVTS curves, to be utilized in the absence or inability to collect mission specific field data.

c. The default LVTS curves for rotary wing aircraft vibration exposure are provided in Tables 514.7C-IX and 514.7D-III of MIL-STD-810G-CN1. The default test spectra are widely used in the Test and Evaluation (T&E) community for laboratory vibration testing of systems that are to be installed in rotary wing aircraft. However, the current default test curves have significant shortcomings, some of the most notable follow:

(1) The current default test spectra date back to the early 1980's. The rotary wing aircraft fleet has changed substantially since that time. Consequently, the 30 year old default specifications are not representative of the modern fleet.

(2) LVTS development techniques were not fully mature at the time the original specifications were developed and excessive conservatism and time compression is a major concern.

** Superscript numbers correspond to Appendix E, References.

(3) Metadata associated with the original LVTS development is very limited. The current default test spectra are not aircraft independent. A single broadband spectra is provided for all rotary wing aircraft platforms. Tonal amplitudes are tabular based solely on engine revolutions per minute (RPM) and blade count.

(4) The current schedules were designed to be extremely conservative.

(a) The mission scenario was based on 2500 hours of flight at "worst case" flight measurements across the fleet.

(b) The test spectra are axis independent. Each axis of the test article is to be subjected to the same test spectra.

(c) Qualification requirements based on highly conservative reference criteria have the strong potential to force excess design conservatism that may lead to undesired residual effects such as unnecessary weight.

d. Shortcomings in the current default Rotary Wing Aircraft LVTS curves necessitate an update to the default test curves currently presented in MIL-STD-810G CN1.

1.2 Implementation Plan.

a. Flight testing and data collection is an expensive venture that can take months if not years of planning and scheduling. Consequently, it is not feasible to release an all new, 100% complete, set of LVTS for all rotary wing aircraft platforms. The U.S. Army Test and Evaluation Command (ATEC) is the Army's test authority and current custodian of MIL-STD-810G-CN1. ATEC's Redstone Test Center (RTC) is updating the default LVTS for rotary wing aircraft. As funding and aircraft are made available, flight testing will be conducted for the purpose of collecting vibration data on the modern rotary wing aircraft fleet. The vibration data will be utilized to develop LVTS for the aircraft. RTC will file the raw field data and worksheets for each LVTS development effort as they are completed. Each completed set of LVTS's will then be added to this TOP in the form of an Appendix. Due to funding limitations it may not be possible to gather data from all regions of an aircraft for which LVTS are needed. In those cases some LVTS will be derived from the data available and application of the concepts and profiles provided in MIL-STD-810G-CN1. The derived profiles will be replaced when addition data are acquired.

b. Details such as close up photographs that could be perceived as too sensitive for public release will not be included in the TOP. In the event such detailed information is required, access to the stored files will be considered based on a need to know basis. Each Appendix will document the final LVTS, Vibration Specification Development (VSD) technique details, and all relevant metadata such as mission scenario and instrumentation locations used in the flight test. Formatting of each Appendix will be kept as uniform as possible. The updated LVTS presented in the Appendices of this TOP will supersede the current defaults listed in Tables 514.7C-IX and 514.7D-III of MIL-STD-810G-CN1.

2. FACILITIES AND INSTRUMENTATION.

The object of this TOP is to provide default vibration criteria for the current rotary wing fleet in the event item specific field data are not available. Dynamic test facilities and associated test equipment and instrumentation will be used for the test execution phase. The facilities of record for the VSD discussed in this TOP are the actual aircraft. The final LVTS's and associated instrumentation details are provided in the Appendices of this TOP.

3. REQUIRED TEST CONDITIONS.

a. For the purposes of the flight data acquisition portion of a LVTS development effort, required conditions are an approved airworthiness release and safe operational conditions. Laboratory test conditions such as test durations and temperature for actual implementation may vary based on the mission requirements of the unit under test (UUT). This document provides the actual vibration levels to which testing shall be conducted.

b. If military personnel are required for testing, determine if Military Occupational Specialty (MOS) qualified Soldier-Operator/-Maintainer Test and Evaluation (SOMTE) personnel assigned to ATEC are available to support the testing. If SOMTE are not available, ensure a Test Schedule and Review Committee (TSARC) request is submitted one year prior to the start of testing, or as early as possible. A Safety Release (SR) must be obtained from the U.S Army Evaluation Center (AEC) prior to using military personnel as flight test participants.

4. TEST PROCEDURES.

Specialized software tools were employed in the development of the LVTS provided in the Appendices of this TOP. These tools are based on the procedures and are in accordance with (IAW) the guidelines of MIL-STD-810G-CN1 Method 514.7 Annex F, and North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 4370 Allied Environmental Conditions and Test Publication (AECTP) 4370 Leaflet 2410/1[2].

5. DATA REQUIRED.

LVTS development requires data collection over the full range of aircraft operational flight to characterize the vibration environment. The characterization typically includes a collection of acceleration time histories of all relevant exposure conditions, and an associated table of exposure times or percentages for those conditions per the LCEP.

6. PRESENTATION OF DATA.

a. The final LVTS's and associated instrumentation details are provided in the Appendices of this TOP. The individual vibration schedules are provided in Power Spectral Density (PSD) format with superimposed sinusoidal components that are associated with the rotor speeds and blade count of each aircraft and other sources. Tones associated with the primary and tail rotors are identified as nP and nT, where n is the associated harmonic. Dominant harmonics are not limited to the 3rd harmonic of the blade passage as in MIL-STD-

810. In addition, attempts were made to identify and include predominant sinusoidal components associated with aircraft specific rotating subcomponents. Note that the list of tones associated with rotating subcomponents is not all inclusive given the sparse measurement accelerometer placement. In the event a unit under test is known to be in very close proximity to a rotating subcomponent that is not included in the specification for the region of interest, it is advised that the subcomponent specific RPM's be researched and the appropriate tone be added to the region specific specification. Select tonal amplitude defaults per the historical guidance (MIL-STD-810) provided in Table 1. In the event there is indecision associated with region, employ the full spectrum as defined in Table 1.

TABLE 1. ON/NEAR DRIVE SYSTEM DEFAULTS (DETERMINE S1 FROM HELICOPTER SPECIFIC ROTATING COMPONENT)

BROADBAND			TONES			
Freq (Hz)	G^2/Hz		Tone # (fx)	Source Freq (Hz)	G-Pk	G-Pk
					(if 5≤fx ≤ 50)	(if fx > 50)
10	0.002		f1	1S	0.1 x S	5+0.01 x fx
100	0.02		f2	2x1S	0.1 x S	5+0.01 x fx
300	0.02		f3	3x1S	0.1 x S	5+0.01 x fx
2000	0.002		f4	4x1S	0.1 x S	5+0.01 x fx

The default test durations and the represented hours of flight are listed with each profile. If the LCEP of the UUT is other than the published default, modify the test duration as appropriate (i.e., for a specification published as a 4 hour test representing 2500 hours of flight, a UUT expected to have an exposure limited to 1250 hours would yield one-half the published test duration). This modification to the default test duration should be limited such that durations are not reduced to less than 30 minutes/axis.

b. All LVTS's provided in the Appendices of this TOP are considered to be Endurance specifications. Such lifecycle testing generally involves use of time compression techniques to yield manageable/affordably laboratory test durations. Care was taken to limit the amount of time compression to avoid raising test amplitudes beyond acceptable levels above maximum field measured data per the guidance in Annex F of MIL-STD-810G-CN1. In most cases, tactical maneuvers that represented low percentages of the LCEP tended to drive the maximum measured levels. In the event Functional testing is to be considered, it is permissible to reduce the test levels provided in the Appendices by an amount which will yield levels representative of maximum measured field levels. The level of reduction to the published endurance specifications will vary based on the amount of time compression employed in deriving the original specification. Refer to section 5 in each aircraft specific Appendix for guidance on the amount of reduction to the published Endurance specification allowable in the conduct of a Functional test.

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APPENDIX A. GLOSSARY.

Term	Definition
Laboratory Vibration Test Schedule	Laboratory Vibration Test Schedule (LVTS) – The LVTS is a plot developed from field data depicting the vibration environment for a specific vehicle location or zone. The plot contains information required to perform a laboratory test on a vibration exciter. Typical information includes: a broadband spectra (or profile), sine or narrowband information (if used), test duration and associated field time represented, control methods and tolerances, and any test specific information required. LVTS are designed to produce fatigue equivalency.
Power Spectral Density	The PSD describes how the power of a signal is distributed with respect to frequency. Vibration control systems typically use PSDs as the control reference; therefore, vibration profiles are generally developed in a PSD format. The PSD is also referred to as the auto spectral density (ASD). See Annex F, Appendix B of MIL-STD-810G CN1 for a description of ASD/PSD calculation methods often used.

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APPENDIX B. ABBREVIATIONS.

ACIP	Airframe Component Improvement Program
AEC	U.S. Army Evaluation Center
AECTP	Allied Environmental Conditions and Test Publication
AOB	angle of bank
ASD	Auto Spectral Density
ATEC	U.S. Army Test and Evaluation Command
BUTT LINE	measurement to the right or left of a structure centerline
CAAS	Common Avionics Architecture System
CDU	control display unit
CN	Change Notice
DAFCS	Digital Advanced Flight Control System
DCU	data concentrator unit
ESCG	engine start center of gravity
ESGW	engine start gross weight
Fc	filter cutoff frequency
Hz	Hertz
IAW	in accordance with
IGE	in ground effect
KCAS	KNOTS Constant Air Speed
LCEP	Life-Cycle Environmental Profile
LVTS	Laboratory Vibration Test Schedule
MFD	multifunctional display
NATO	North Atlantic Treaty Organization
NIST	National Institute of Standards and Technology
Nr	Rotor Speed
OGE	out of ground effect
P	sinusoid associated with the primary rotor frequency or harmonic
PSD	Power Spectral Density
RPM	revolutions per minute

APPENDIX B. ABBREVIATIONS.

RTC	Redstone Test Center
SOMTE	Soldier-Operator/-Maintainer Test and Evaluation
SOR	sine-on-random
SPS	samples per second
SR	Safety Release
STANAG	Standardization Agreement
STATION	measurement from the front to the rear of a structure
T	sinusoid associated with the tail rotor frequency or harmonic
T&E	Test and Evaluation
TOP	Test Operations Procedure
TSARC	Test Schedule and Review Committee
UUT	unit under test
VH	maximum speed in level flight with maximum continuous power
VSD	Vibration Specification Development
WATERLINE	measurement of height on a structure
ZFCG	zero fuel center of gravity

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

C.1 TEST ITEM.

The test item for this VSD effort was a CH-47F Chinook, Aircraft 09-088792 (Figure C-1). The aircraft takeoff gross weight was 33,092 lbs and the Zero Fuel Center of Gravity (ZFCG) was 332.3 inches. Maintenance Work Orders (MWO) and Service Bulletins (SB) performed on the test aircraft are listed in Table C-1. The CH-47F is a twin turbine engine, tandem-rotor helicopter designed for transportation of cargo, troops, and weapons during day, night, visual and instrument meteorological conditions. The helicopter is equipped with two production Honeywell (formerly AlliedSignal) T55-GA-714A engines. The two engines simultaneously drive tandem, three-bladed, counter-rotating rotors through engine transmissions, a combining transmission, and drive-shafting to the forward and aft transmissions. The engine and transmission data are calculated and transmitted by the data concentrator units (DCUs) and displayed for the pilots to view on any of the five multifunction displays (MFDs). Similarly, the amount of fuel remaining, engine torques, and other aircraft vitals are reported to the MFDs by the DCUs. The aircraft uses a Digital Advanced Flight Control System (DAFCS) that incorporates an optimized consolidation of previously fielded CH-47 Chinook control laws to reduce actuator saturation, improve handling qualities during low-speed flight, and assist pilotage in degraded visual environments. This information is integrated with the communication and navigation functions by the Common Avionics Architecture System (CAAS). Two control display units (CDUs) with alphanumeric keyboards are provided for pilots to input flight, mission, and system data into the CAAS. Each control display unit is capable of both simultaneous and independent operation.

Figure C-1. CH-47 Chinook Helicopter.

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

TABLE C-1. CH-47F AIRCRAFT 09-088792 MWO AND SB

MWO OR SB NUMBER	SHORT TITLE
01152024050115	ARMOR SEAT COMPENSATOR (H-47)
01152024050117	AVA TRACKER BRACKET (CH47D/F)
01152027150001	M4 RIFLE MOUNT INSTALLATION (CH-47F)
01152027150002	L/H CREW SEAT SYS INST
01152027150003	AFT PYLON DR UPPER LTCH
01152027150005	STALK LIGHT ADAPTER PLATE
01152027150006	P3 DRAIN LINE INSTALLATION
01152027150007	R/H CRASHWORTHY CREW SEAT
01152027150009	FUEL CROSSFEED BREAKAWAY FITTING
01152027150010	CMWS 5TH SENSOR (CH-47F)
01152027150011	CH47 IR SUPPRESSION SYS
01152027150012	AN/ARC-231 (V) C
01152027150017	ATIRCM-F
01152027150021	AUDIO PANEL (CAP) KNOB GUARD RAILS
01152027150022	EAWIS (CH47F)
01152027150024	CVDR UPGRADE
01152027150025	MFCU COVERS
01152027150026	CARGO PLATFORM HEALTH ENV (CPHE)
01152027150027	CAAS UPGRADE 8.4.6
SB-724-53-1024	C-BOX BEAM REPAIR

C.2 SUPPORTING DATA ANALYSIS SOFTWARE.

The software tools used to derive the LVTS in this document were developed IAW the guidelines of MIL-STD-810G-CN1 Method 514.7 Annex F, and NATO STANAG 4370 Leaflet 2410. Calibration of the individual test equipment associated with the data acquisition was performed through the U.S. Army's Test, Measurement, and Diagnostic Equipment Program or via subcontract to accredited calibration laboratories. Calibration was performed IAW the original manufacturer's established standards and procedures for original equipment performance, with standard test equipment and laboratory standards traceable to the National Institute of Standards and Technology (NIST). The validity of equipment calibration was verified prior to test.

C.3 TEST OBJECTIVE.

The objective of the test was to develop new LVTS for the CH-47F platform to supersede the legacy vibration test levels presented in MIL-STD-810G CN1. The testing effort was completed in two phases:

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

a. Collected vibration data at locations of interest on the CH-47F during flight testing. Flight testing encompassed maneuvers that provided a good representation of the Mission Scenario.

b. Utilized flight test data to develop vibration specifications for the CH-47F.

C.4 DETAILS OF FLIGHT TEST.

C.4.1 Flight Maneuvers.

An effort was made to hold each test point for a minimum of 30 seconds in order to provide optimal statistical averaging for PSD calculations; however, due to the inherent nature of some of the test points, this was not possible for all test maneuvers. Overlap processing was employed to maximize the number of averages in the PSD calculations.

C.4.2 Instrumentation.

a. Instrumentation locations on the CH-47F were selected in an effort to capture the overall vibration levels on the aircraft. Due to programmatic constraints for this effort, instrumentation was limited to 24 triaxial accelerometers. Particular care was taken to collect sufficient data in the cockpit and cargo area of the aircraft. One trade-off to this was fewer data collection points around the engine and drive train components of the aircraft. A detailed list of instrumentation locations can be found in Table C-2, and Figure C-2. Observe that the filter cutoff frequency (Fc) was raised to 1953 Hz for accelerometer locations in the engine and transmission locations as higher frequency response was anticipated. A list of aircraft parameters measured is provided in Table C-3.

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

TABLE C-2. CH-47F INSTRUMENTATION LOCATIONS

ACCEL NUMBER	LOCATION DESCRIPTION	RANGE (g)	SAMPLE RATE (SPS)	Fc (Hz)
VIB 1	Nose – Light Distribution Support Bracket	±20	7812.5	1302.1
VIB 2	Cockpit Floor Left Support Beam	±20	7812.5	1302.1
VIB 3	Cockpit Floor Right Support Beam	±20	7812.5	1302.1
VIB 4	Cockpit LHS Instrument Panel	±20	7812.5	1302.1
VIB 5	Cockpit Center Control Panel	±20	7812.5	1302.1
VIB 6	Cockpit Overhead Console	±20	7812.5	1302.1
VIB 7	Left Avionics Closet Lower – Station 120	±20	7812.5	1302.1
VIB 8	Left Avionics Closet Upper – Station 120	±20	7812.5	1302.1
VIB 9	Behind Right Pilot Seat – Heater Tie in Pt	±20	7812.5	1302.1
VIB 10	Station 160 Blkhd (Top)	±20	7812.5	1302.1
VIB 11	Station 320 Blkhd (Top)	±20	7812.5	1302.1
VIB 12	Station 482 Blkhd (Right Side)	±20	7812.5	1302.1
VIB 13	Fwd Cargo Floor (Tie Down Point)	±20	7812.5	1302.1
VIB 14	Mid Cargo Floor (Tie Down Point)	±20	7812.5	1302.1
VIB 15	Aft Cargo Floor (Tie Down Point)	±20	7812.5	1302.1
VIB 16	Center Hook Support Beam Interface	±20	7812.5	1302.1
VIB 17	Fwd Right Landing Gear Hardpoint	±20	7812.5	1302.1
VIB 18	Combining Transmission Fan	±50	7812.5	1953.1
VIB 19	Aft Transmission Mount Fwd Side	±50	7812.5	1953.1
VIB 20	Aft Transmission Fan	±50	7812.5	1953.1
VIB 21	Right Engine Fwd Mount	±50	7812.5	1953.1
VIB 22	Right Engine Aft Mount	±50	7812.5	1953.1
VIB 23	Fwd Pylon Near Vertical Shaft	±50	7812.5	1953.1
VIB 24	Aft Pylon Near Vertical Shaft	±50	7812.5	1953.1

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

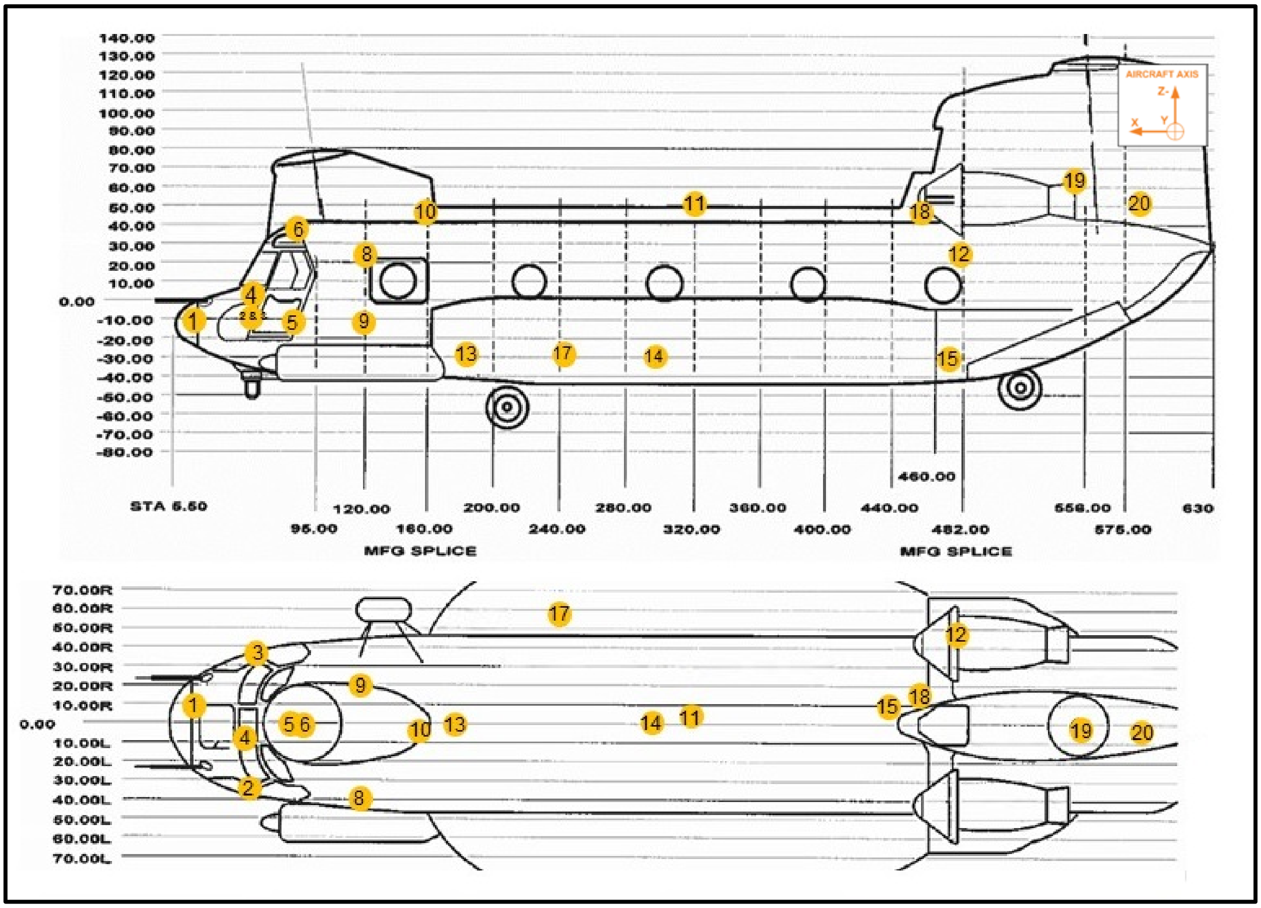


Figure C-2. Accelerometer locations.

TABLE C-3. CH-47F 1553 BUS PARAMETER LIST

MNEMONIC	DESCRIPTION	UNITS	SPS
EGI1GPSLAT	LATITUDE	Radians	20
EGI1GPSLONG	LONGITUDE	Radians	20
EGI1EGRALT	ALTITUDE	Feet	20
EGI1AS	AIRSPEED	Knots	20
EGI1ROLLANGLE	ROLL ANGLE	Degrees	20
EGI1PITCHANGLE	PITCH ANGLE	Degrees	20
EGI1HEAD	HEADING	Degrees	20
EGI1ROLLRATE	ROLL RATE	Degrees/Sec	20
EGI1PITCHRATE	PITCH RATE	Degrees/Sec	20
EGI1YAWRATE	YAW RATE	Degrees/Sec	20

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

b. A posttest data quality review of the flight data indicated problems with the data acquired on the Left Avionics Closet Lower - Station 120, Center Hook Support Beam Interface, Right Engine Aft Mount, Fwd Pylon Near Vertical Shaft, and Aft Pylon Near Vertical Shaft locations. These locations were not included in the LVTS.

C.4.3 Flight Test.

Flight testing was conducted by RTC on 12 March 2015 and 16 March 2015.

C.5 DETAILS OF VIBRATION SPECIFICATION DEVELOPMENT.

C.5.1 Methodology.

The techniques in the code employed to compute the subject LVTS's are in accordance with the recommendations of MIL-STD-810G-CN1 Method 514.7, Annex F. Copies of all field data and CH-47F specific macros were saved and filed.

C.5.2 Mission Scenario.

The maneuvers flown during flight testing were chosen to provide a representation of the expected CH-47F usage spectrum. These flight maneuvers were each assigned a percentage value that correlates the flight maneuver to the total expected exposure over the lifecycle of the test article. The LVTSs were developed to be equivalent to a total of 2500 flight hours on the CH-47F platform. The Mission Scenario utilized in the VSD process was based off the aircraft usage spectrum provided in Table 1 of Boeing Document Number D125-10011-1, "CH-47 Block II Airframe Component Improvement Program (ACIP) Aircraft Usage Spectrum"[3] and discussions with Military Pilots. The Mission Scenario utilized in the VSD can be found in Table C-4. Factors such as airspeed and angle of bank were verified per the 1553 bus parameters as listed in Table C-3.

TABLE C-4. CH-47F MISSION SCENARIO

MANEUVER DESCRIPTION	SCENARIO TIME
Ground (Engines: FLY)	2.95%
Taxi	0.55%
Take off	0.60%
IGE Hover	3.93%
OGE Hover	3.93%
500 fpm Climbs VY	1.50%
1000 fpm Climbs VY	1.50%
1500 fpm Climbs VY	4.40%
60 KCAS	25.73%
0.6 VH	4.60%

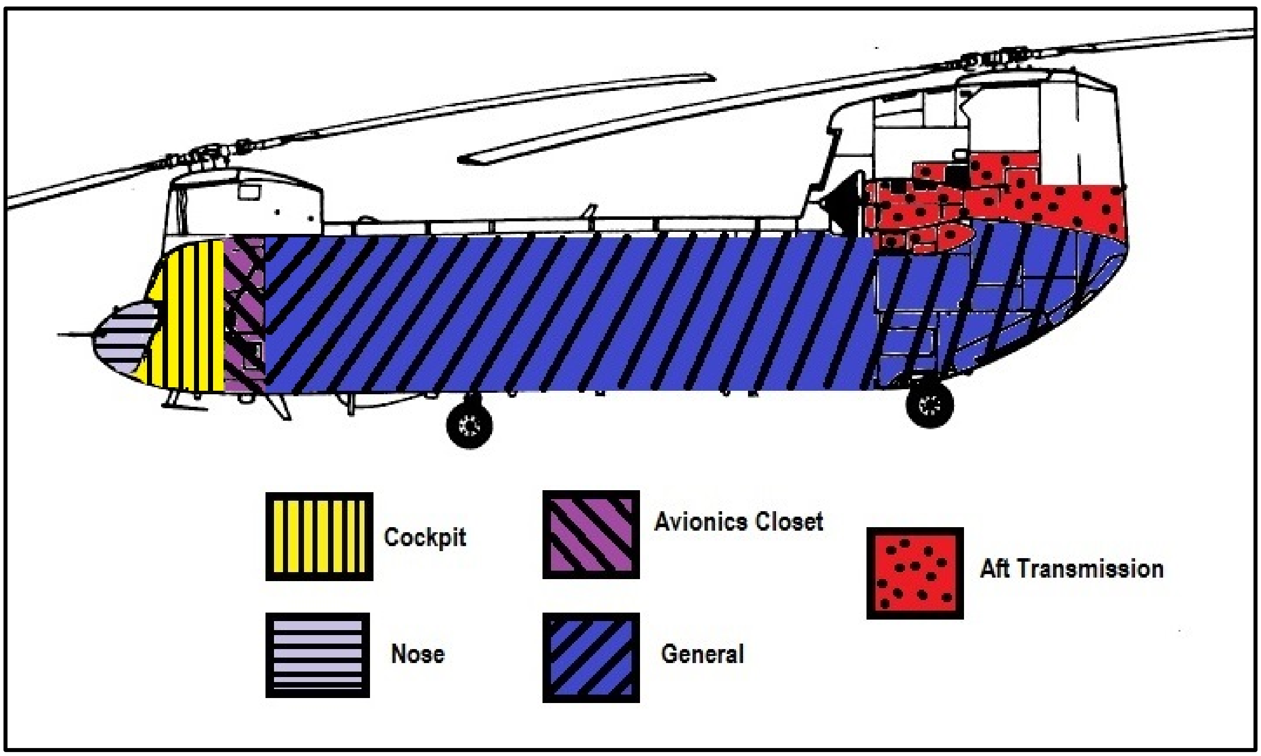
APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

MANEUVER DESCRIPTION	SCENARIO TIME
0.8 VH	8.20%
VH	14.66%
45° Right Turn 80 KCAS	0.58%
45° Left Turn 80 KCAS	0.58%
45° Right Turn 120 KCAS	0.86%
45° Left Turn 120 KCAS	0.86%
1500 fpm descent VY	2.28%
1000 fpm descent VY	2.28%
1500 fpm descent VY	2.28%
2000 fpm descent VY	2.28%
10 KGS Fwd	0.22%
20 KGS Fwd	0.22%
30 KGS Fwd	0.22%
45 KGS Fwd	2.34%
20 KGS Left	0.10%
30 KGS Left	0.10%
45 KGS Left	0.10%
20 KGS Right	0.10%
30 KGS Right	0.10%
45 KGS Right	0.10%
20 KGS Aft	0.10%
30 KGS Aft	0.10%
40 KGS Aft	0.10%
60° Right Turn 80 KCAS	1.00%
60° Left Turn 80 KCAS	1.00%
60° Right Turn 120 KCAS	0.91%
60° Left Turn 120 KCAS	0.91%
45° Right Turn VH	1.43%
45° Left Turn VH	1.43%
Combat Man. Decelerating Turns	0.50%
Combat Man. Break Turn	0.50%
Combat Man. Dive	0.50%
Combat Man. Recovery	0.50%
Autorotation (10K-2,500 ft AGL)	2.00%
Land	0.90%
TOTAL:	**100%**

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

C.5.3 Location Groupings.

In the VSD process a determination must be made as to when and where to group data locations together in producing LVTS's for specific regions of the aircraft. Data collection points were grouped together in the VSD process as shown in Figure C-3 and Table C-5. The final LVTS's were established by taking a spectral line by spectral line maxi of the individual LVTS's developed within each zone on a per axis basis.



Note: Regions shown are for general guidance only and are not intended to provide definitive profile selection.

Figure C-3. Aircraft Regions.

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

TABLE C-5. ACCELEROMETER VSD GROUPINGS

AIRCRAFT REGION	ACCEL NUMBER	LOCATION DESCRIPTION	STATION (INCHES)	WATER LINE (INCHES)	BUTT LINE (INCHES)
Nose	VIB 1	Nose - Light Distribution Support Bracket	35	-13	10R
Cockpit / Instrument Panel	VIB 2	Cockpit Floor Left Support Beam	53	-10	39L
	VIB 3	Cockpit Floor Right Support Beam	53	-10	39R
	VIB 4	Cockpit LHS Instrument Panel	50	5	9L
	VIB 5	Cockpit Center Control Panel	75	-12	0
	VIB 6	Cockpit Overhead Console	88	38	0
Avionics Closet	VIB 8	Left Avionics Closet Upper - Station 120	120	27	39L
	VIB 9	Behind Right Pilot Seat - Heater Tie in Point	120	-10	18R
General	VIB 10	Station 160 Blkhd (Top)	160	50	1L
	VIB 11	Station 320 Blkhd (Top)	320	50	1R
	VIB 12	Station 482 Blkhd (Right Side)	482	25	47R
	VIB 13	Fwd Cargo Floor (Tie Down Point)	182	-30	0
	VIB 14	Mid Cargo Floor (Tie Down Point)	300	-30	0
	VIB 15	Aft Cargo Floor (Tie Down Point)	480	-30	0
	VIB 17	Fwd Right Landing Gear Hardpoint	250	-30	57R
Aft Transmission	VIB 18	Combining Transmission Fan	450	55	11R
	VIB 19	Aft Transmission Mount Fwd Side	550	65	13L
	VIB 20	Aft Transmission Fan	584	50	5L
External Stores	Insufficient data were available to develop LVTS for this region. The LVTS provided were derived by applying scaling factors to the General LVTS. The scaling factors (1.5 for sine tones, 2 for broadband breakpoints) were based on the ration of the External Stores and General profiles in MIL-STD-810G-CN1.				
On/Near Drive System Elements	Refer to Table 1 Defaults.				

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

C.5.4 VSD Results.

a. The spectral content of the vibration energy for the locations of interest on the CH-47F was Sine-On-Random (SOR) in nature. The sine portion of the vibration energy was primarily driven by the main rotors of the CH-47F. As the rotor speeds have minimal variability, the sine portion of the SOR specification is tonal (does not sweep). The frequency of the dominant sinusoidal content was constant and driven by the nominal rotor passage frequency of 3.8 Hertz (Hz). The nature of the vibration data dictated the development of a SOR laboratory vibration test with stationary sinusoidal tones.

b. All reference levels in this Appendix were compared to the measured field levels to ensure acceptable ratios between the final specifications and maximum measured levels were met per the guidance in MIL-STD-810G-CN1 ANNEX F. This criteria was met while maintaining a specified test duration of 4.0 hours (representing 2500 hours of flight) which was consistent with previous MIL-STD-810 default helicopter vibration specification test durations. Should the default test times be modified, refer to the guidance in Section 6 of the body of this TOP.

c. LVTSs were produced for each of the three mutually orthogonal translational axes (x-axis or longitudinal with respect to the aircraft, y-axis or translational to the aircraft, and z-axis or vertical with respect to the aircraft). For a complete 2500 flight hour laboratory lifecycle vibration replication, the test item should be subjected to all three LVTS axes.

d. Care should be taken when selecting a test profile from the default profiles provided to ensure it is appropriate for use for the article under test. Consider the planned deployment location of the test article on the CH-47F and select the default LVTS in the associated zone of interest. When it is unclear which of the default profiles should be utilized for a test item the General LVTS should be selected. For test articles where aircraft orientation may be unknown or not fixed, it is recommended that each axis of the test article be tested to the envelope of all possible axes of aircraft orientation for that test article. For example, for cargo in which placement relative to the aircraft orientation between x and y are unknown, it is recommended that both x and y axes of the cargo be tested to the envelope of the longitudinal and transverse LVTS for the zone of interest.

C.5.5 Functional Test Considerations

In the calculation of the sine reference levels, a conservatism factor of 1.2 was applied to the sine tones to account for unknowns and the fact that only a single vehicle was employed in acquisition of the field data from which the LVTSs were derived. In addition, Miner-Palmgern techniques were employed to compress the test duration to 4 hours per axis as discussed above. The resulting ratio of LVTS reference levels to maximum measured levels will vary across tones for each frequency of interest. This eliminates the ability to define a constant level for reducing endurance vibration levels to Functional vibration levels for all tones while maintaining a direct

APPENDIX C. CH-47F LABORATORY VIBRATION TEST SCHEDULES.

fatigue equivalence. The trends in the ratios of final specification to maximum measured field data for the CH-47F LVTS development were reviewed. Based on this review, a reduction of 2 dB from the LVTSs provided in this Appendix will yield laboratory levels comparable to maximum measured field data (conservatism included) and is recommended for implementation of Functional testing. Test time associated with Functional testing should be kept to a minimum and is generally not considered as part of the Endurance test duration.

C.5.6 Reliability Test Considerations.

a. The LVTSs as published in this TOP have been compressed to provide the equivalent of 2500 hours of flight in four hours of runtime per axis. For reliability testing it is sometimes desired to operate a test item for hundreds of hours in an environment "representative" of actual exposure (i.e., uncompressed vibration). Testing at the levels recommended for functional testing is not appropriate as that would be the equivalent of running at near maximum levels for the full duration.

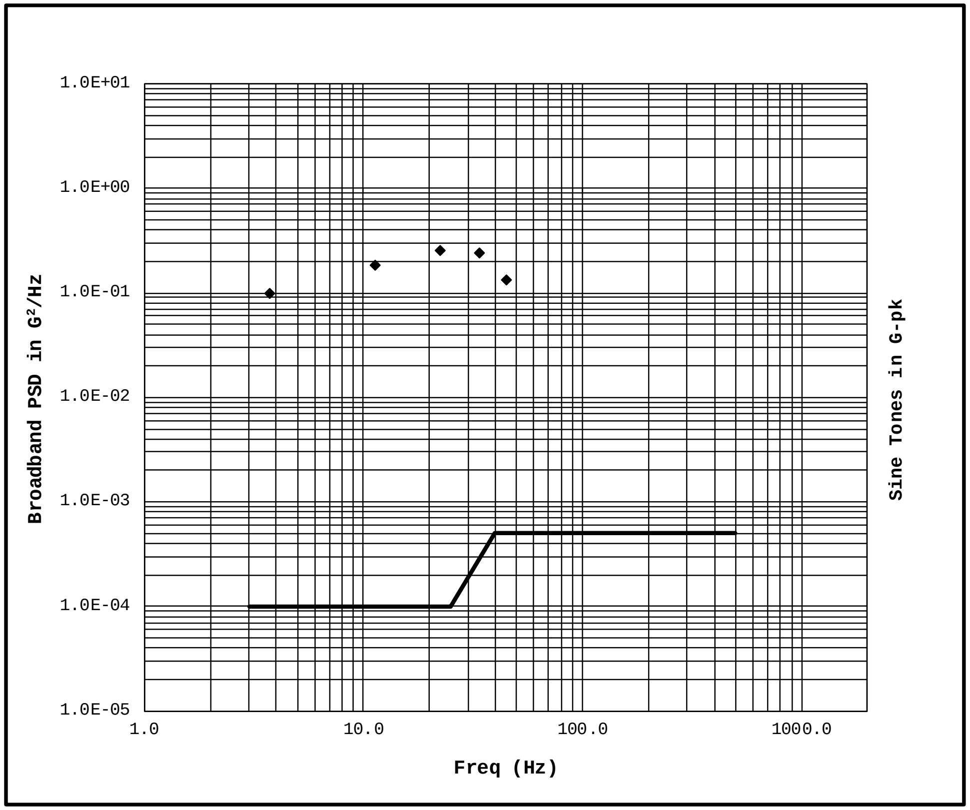
b. In the process of establishing reference criteria for a reliability test, while backing out sufficient compression to yield representative field levels, it is desired to maintain a reasonable fatigue equivalency. Dealing with uncompressed 1-DOF references, laboratory run time will be 3:1 longer than the actual equivalent flight time. If one applies Miner-Palmgren techniques using the exponent associated with sinusoidal excitation (m=6.43) and assuming 1/3 of the 2500 flight hours (833 hours) of laboratory time per axis, the published references would be run at -7.21 dB. The resulting 2500 hours of laboratory run time would represent 2500 hours of flight in this case. Realizing that the exponent in Miner-Palmgren differs for sine and random signals and understanding the proposed levels for a reliability test are being defined while maintaining reasonable fatigue equivalency it is recommended that a 7 dB reduction at a duration of 833 hrs/axis (representing 2500 hours) be employed as a basis. Any reliability test to be conducted at an arbitrary number of desired hours may be computed by simply linearly scaling time. For example, if one desired to conduct a reliability test for 1500 hours, the published specs would be executed at -7 dB and the duration per axis would be 500 hrs.

C.6 SUMMARY OF RESULTS.

LVTSs were developed for the CH-47F Chinook and are included as Figures C-4 through C-21. In the event LVTSs are required for other variants of the CH-47, the ideal solution would be to develop them based on measured field data. In the absence of such data, the schedules provided in this document may serve as an alternative. Sine tone frequencies may require slight modification if the rotor head frequency of the variant is other than 225 RPM (Nr=3.75 Hz), as in the case of the CH-47F used in this LVTS development.

CH-47F LVTS
Aircraft Region: Nose
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-04
25.0	1.00E-04
40.0	5.00E-04
500.0	5.00E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Peak**
1P	3.75	0.10
3P	11.25	0.18
6P	22.50	0.26
9P	33.75	0.24
12P	45.00	0.13

Broadband Info

Grms (Grms)	0.49
Max Vel (in/sec)	1.23
Max Disp (In Pk-Pk)	0.07

Sine Tone Info

Max Vel (in/sec)	1.64
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

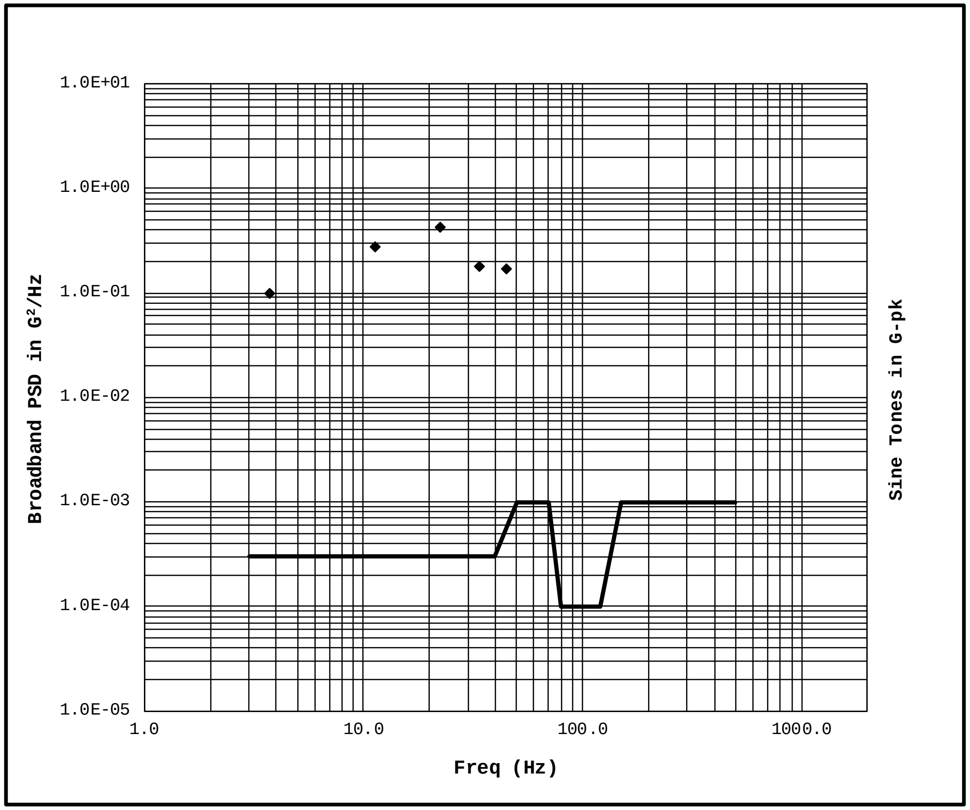
Figure C-4. CH-47F LVTS, Region: Nose; Axis: Long.

CH-47F LVTS

Aircraft Region: Nose

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	3.00E-04
40.0	3.00E-04
50.0	1.00E-03
70.0	1.00E-03
80.0	1.00E-04
120.0	1.00E-04
150.0	1.00E-03
500.0	1.00E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Peak**
1P	3.75	0.10
3P	11.25	0.28
6P	22.50	0.42
9P	33.75	0.18
12P	45.00	0.17

Broadband Info

Grms (Grms)	0.64
Max Vel (in/sec)	1.91
Max Disp (In Pk-Pk)	0.11

Sine Tone Info

Max Vel (in/sec)	1.64
Max Disp (in Pk-Pk)	0.14

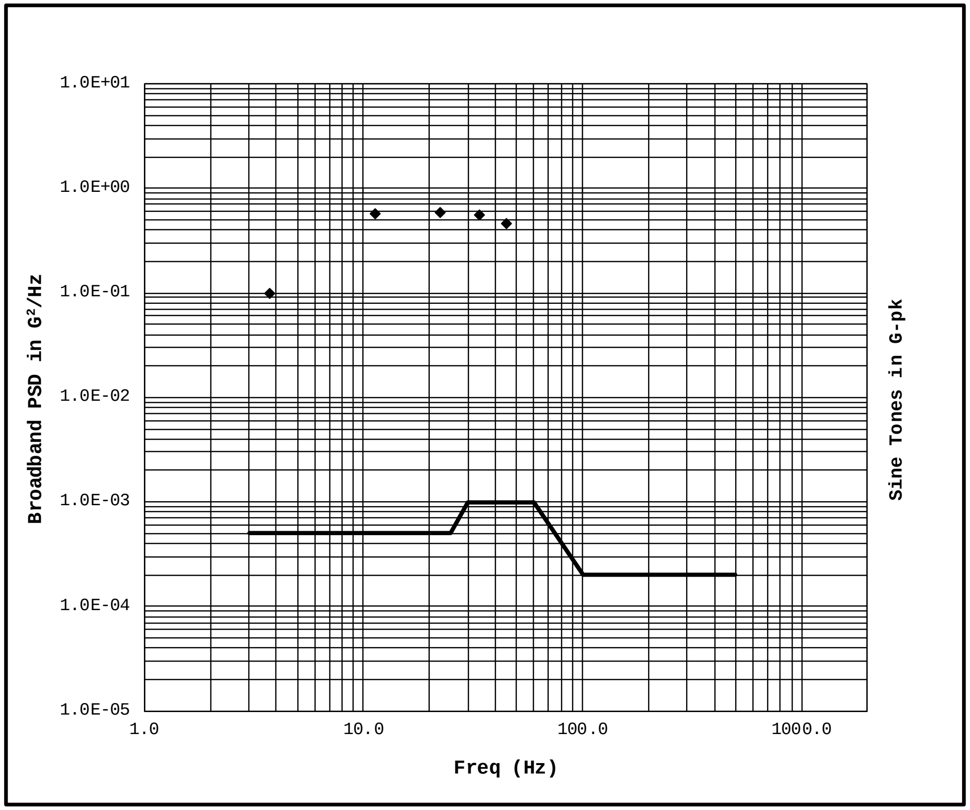
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-5. CH-47F LVTS, Region: Nose; Axis: Transverse.

CH-47F LVTS
Aircraft Region: Nose
Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	5.00E-04
25.0	5.00E-04
30.0	1.00E-03
60.0	1.00E-03
100.0	2.00E-04
500.0	2.00E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Peak**
1P	3.75	0.10
3P	11.25	0.56
6P	22.50	0.59
9P	33.75	0.56
12P	45.00	0.46

Broadband Info

Grms (Grms)	0.38
Max Vel (in/sec)	2.43
Max Disp (In Pk-Pk)	0.15

Sine Tone Info

Max Vel (in/sec)	3.08
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

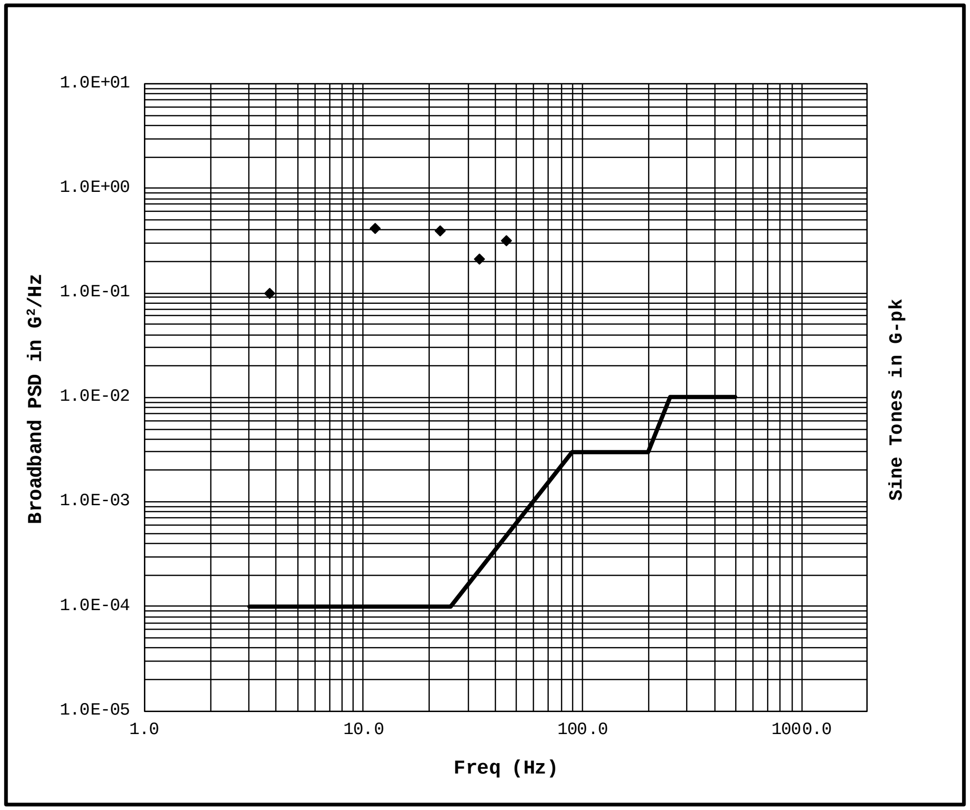
Figure C-6. CH-47F LVTS, Region: Nose; Axis: Vertical.

CH-47F LVTS

Aircraft Region: General

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-04
25.0	1.00E-04
90.0	3.00E-03
200.0	3.00E-03
250.0	1.00E-02
500.0	1.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.41
6P	22.50	0.39
9P	33.75	0.21
12P	45.00	0.32

Broadband Info

Grms (Grms)	1.79
Max Vel (in/sec)	1.76
Max Disp (In Pk-Pk)	0.07

Sine Tone Info

Max Vel (in/sec)	2.26
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

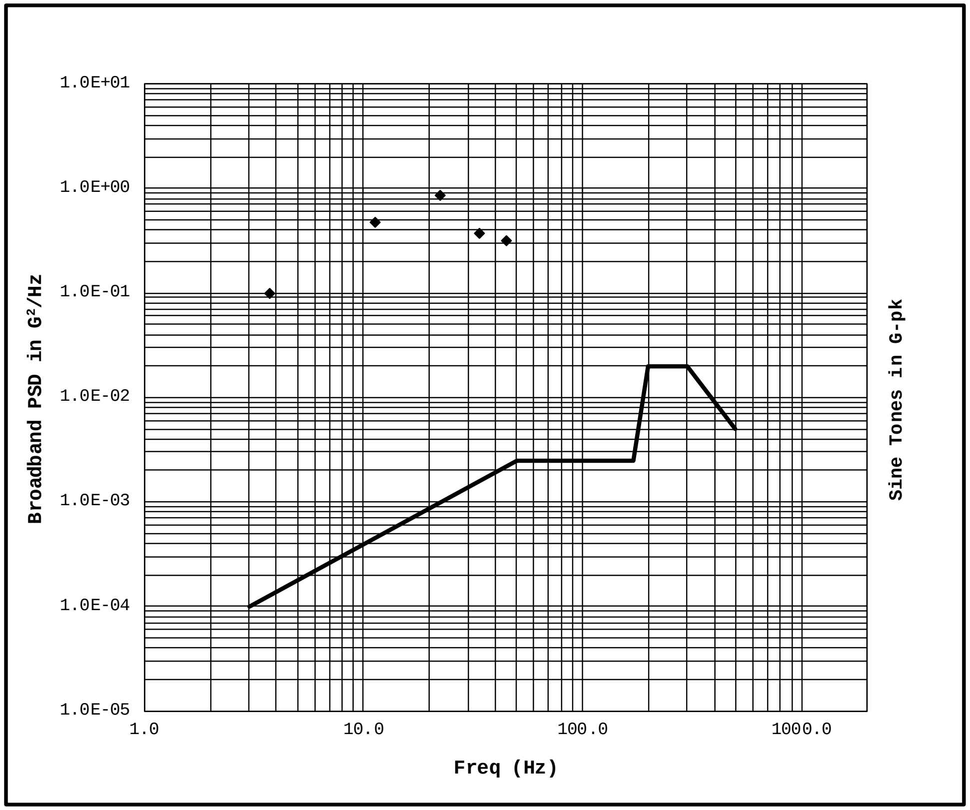
Figure C-7. CH-47F LVTS, Region: General; Axis: Long.

CH-47F LVTS

Aircraft Region: General

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-04
50.0	2.50E-03
170.0	2.50E-03
200.0	2.00E-02
300.0	2.00E-02
500.0	5.00E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.47
6P	22.50	0.86
9P	33.75	0.37
12P	45.00	0.32

Broadband Info

Grms (Grms)	2.16
Max Vel (in/sec)	2.65
Max Disp (In Pk-Pk)	0.08

Sine Tone Info

Max Vel (in/sec)	2.59
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-8. CH-47F LVTS, Region: General; Axis: Transverse.

CH-47F LVTS

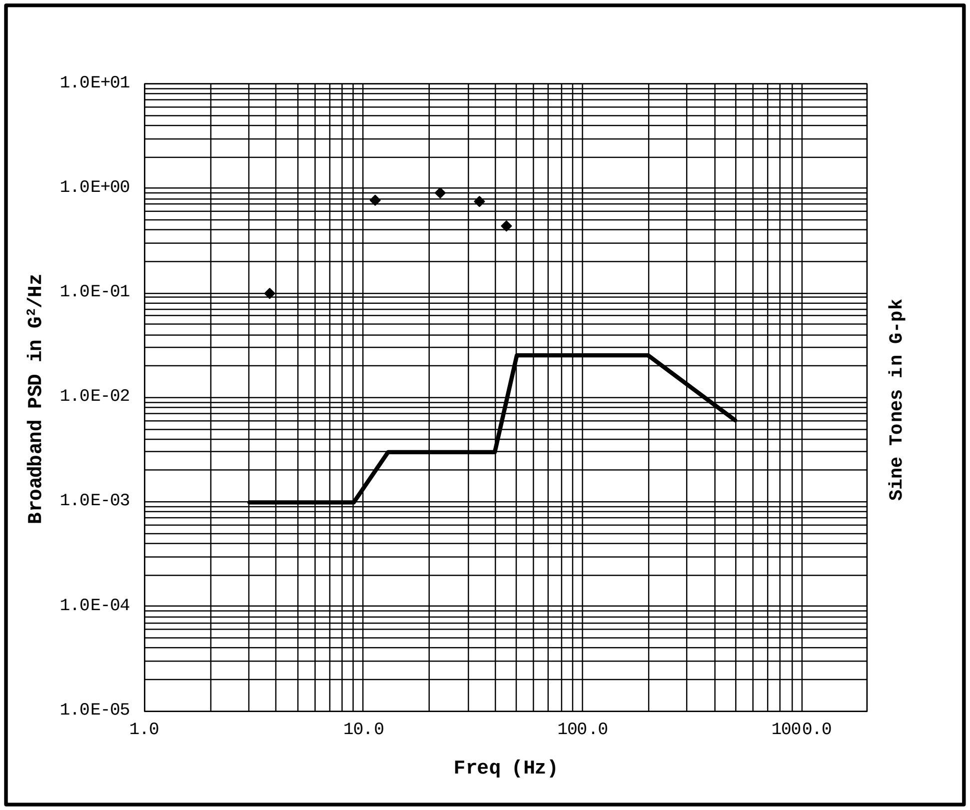
Aircraft Region: General

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-03
9.0	1.00E-03
13.0	3.00E-03
40.0	3.00E-03
50.0	2.50E-02
100.0	2.50E-02
120.0	2.50E-02
200.0	2.50E-02
500.0	6.00E-03

Broadband Info

Grms (Grms)	2.75
Max Vel (in/sec)	5.55
Max Disp (In Pk-Pk)	0.21



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.77
6P	22.50	0.90
9P	33.75	0.75
12P	45.00	0.44

Sine Tone Info

Max Vel (in/sec)	4.20
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

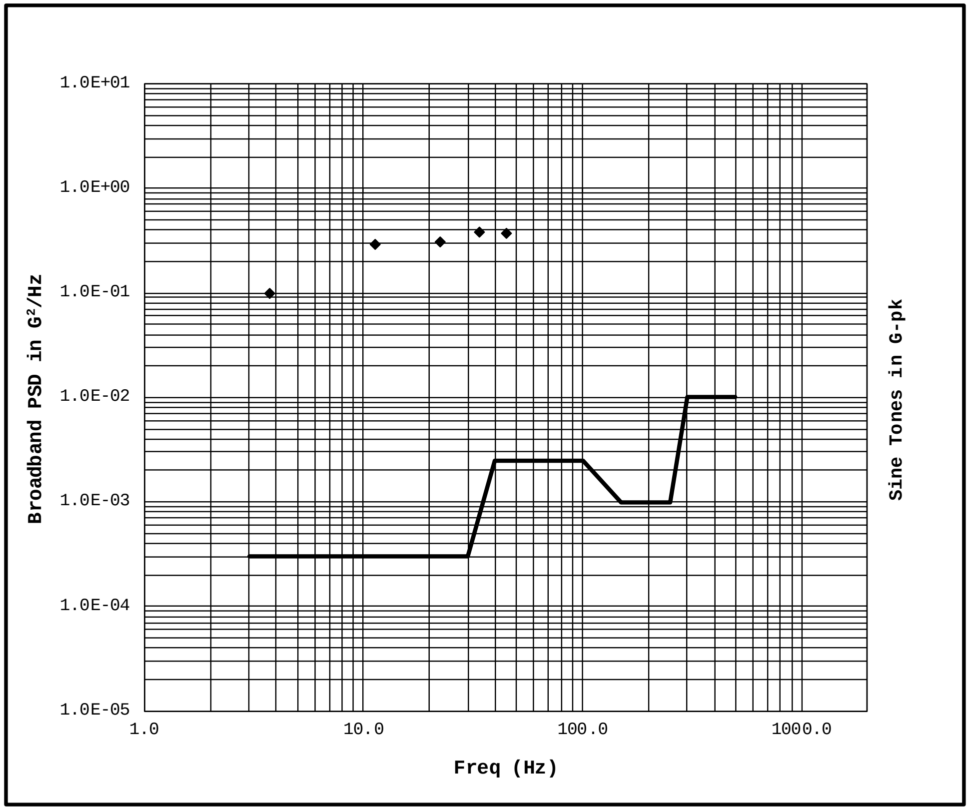
Figure C-9. CH-47F LVTS, Region: General; Axis: Vertical.

CH-47F LVTS

Aircraft Region: Cockpit

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	3.00E-04
30.0	3.00E-04
40.0	2.50E-03
100.0	2.50E-03
150.0	1.00E-03
250.0	1.00E-03
300.0	1.00E-02
500.0	1.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.29
6P	22.50	0.31
9P	33.75	0.39
12P	45.00	0.37

Broadband Info

Grms (Grms)	1.60
Max Vel (in/sec)	2.33
Max Disp (In Pk-Pk)	0.11

Sine Tone Info

Max Vel (in/sec)	1.64
Max Disp (in Pk-Pk)	0.14

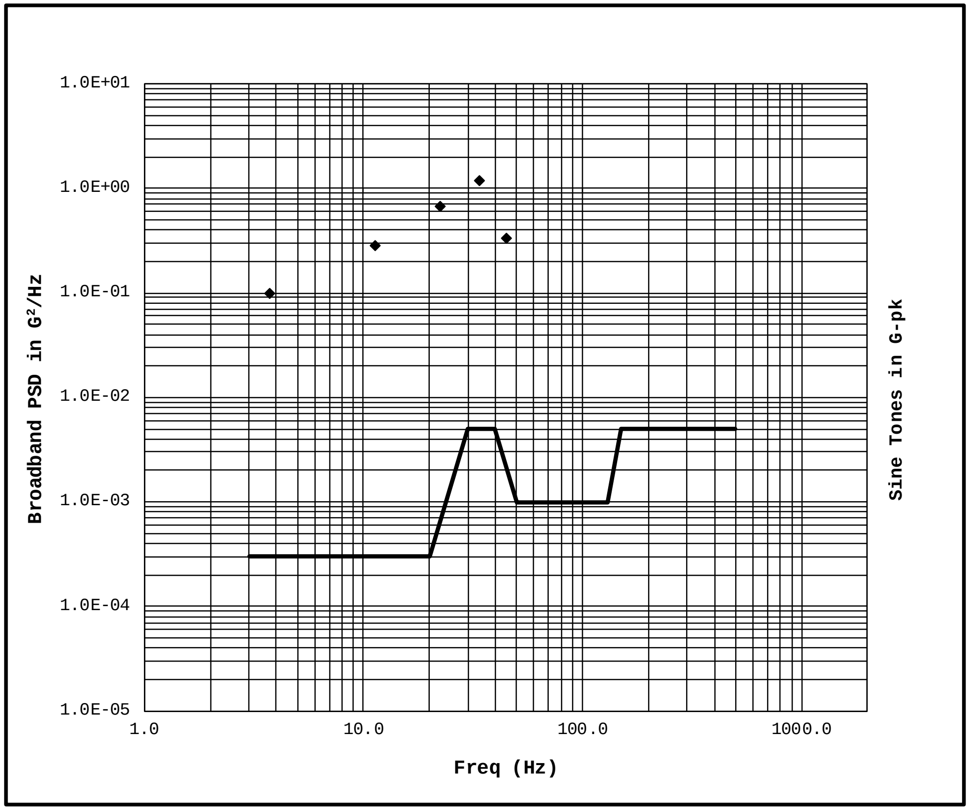
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-10. CH-47F LVTS, Region: Cockpit; Axis: Long.

CH-47F LVTS
Aircraft Region: Cockpit
Axis: Transverse

Broadband - PSD	
Freq(Hz)	G^2/Hz
3.0	3.00E-04
20.0	3.00E-04
30.0	5.00E-03
40.0	5.00E-03
50.0	1.00E-03
130.0	1.00E-03
150.0	5.00E-03
500.0	5.00E-03



Sine Tones - G-Peak		
Tone	Freq(Hz)	G-Pk
1P	3.75	0.10
3P	11.25	0.28
6P	22.50	0.68
9P	33.75	1.19
12P	45.00	0.33

Broadband Info

Grms (Grms)	1.41
Max Vel (in/sec)	2.63
Max Disp (In Pk-Pk)	0.11

Sine Tone Info

Max Vel (in/sec)	2.17
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

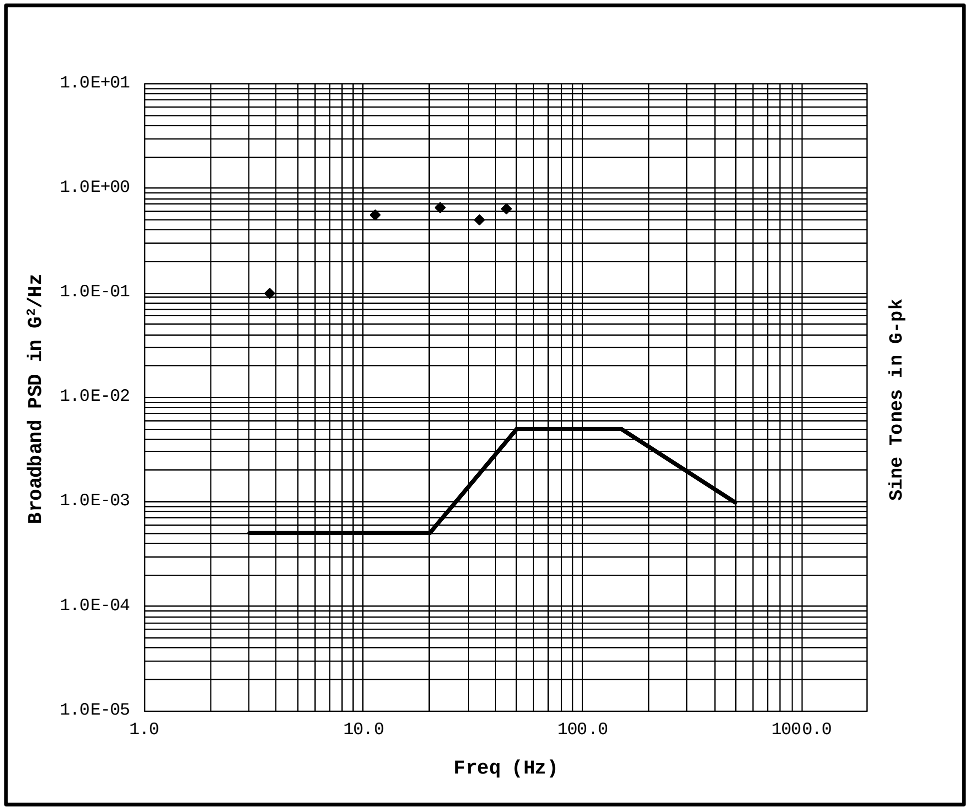
Figure C-11. CH-47F LVTS, Region: Cockpit; Axis: Transverse.

CH-47F LVTS

Aircraft Region: Cockpit

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	5.00E-04
20.0	5.00E-04
50.0	5.00E-03
150.0	5.00E-03
500.0	1.00E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.56
6P	22.50	0.65
9P	33.75	0.50
12P	45.00	0.64

Broadband Info

Grms (Grms)	1.15
Max Vel (in/sec)	3.04
Max Disp (In Pk-Pk)	0.15

Sine Tone Info

Max Vel (in/sec)	3.05
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-12. CH-47F LVTS, Region: Cockpit; Axis: Vertical.

CH-47F LVTS

Aircraft Region: Avionics Closet

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-04
20.0	2.00E-04
60.0	3.00E-03
120.0	3.00E-03
250.0	2.00E-04
350.0	2.00E-04
380.0	2.00E-03
420.0	2.00E-03
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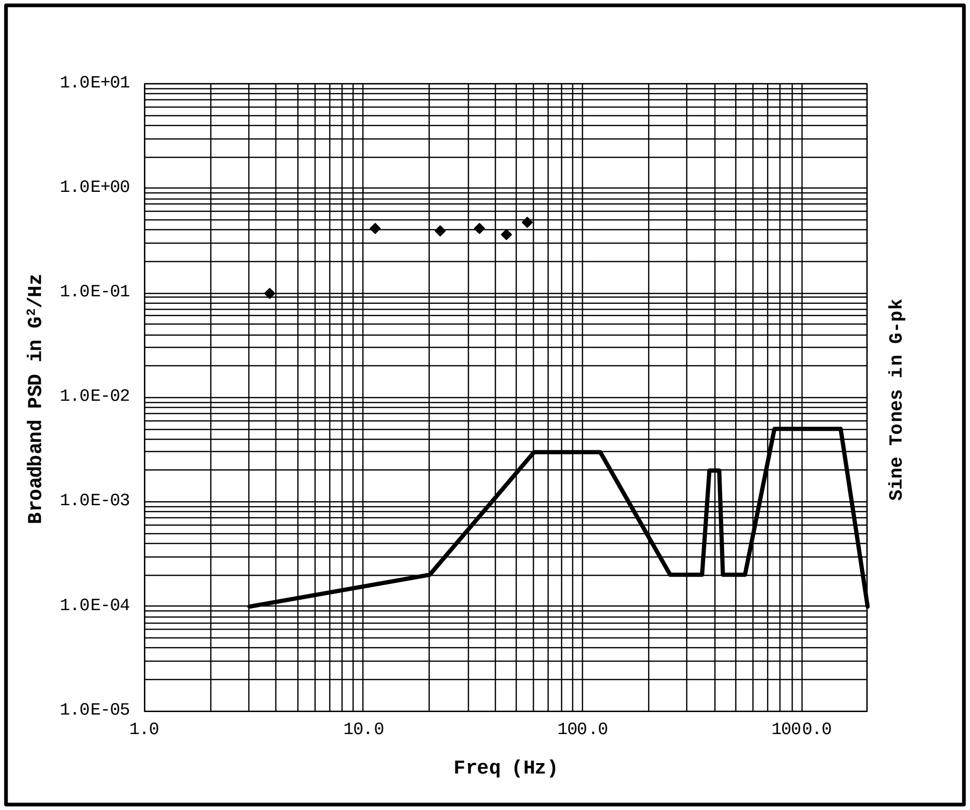
2000.0	1.00E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.41
6P	22.50	0.39
9P	33.75	0.42
12P	45.00	0.36
15P	56.25	0.47

Broadband Info

Grms (Grms)	2.27
Max Vel (in/sec)	1.84
Max Disp (In Pk-Pk)	0.07

Sine Tone Info

Max Vel (in/sec)	2.26
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

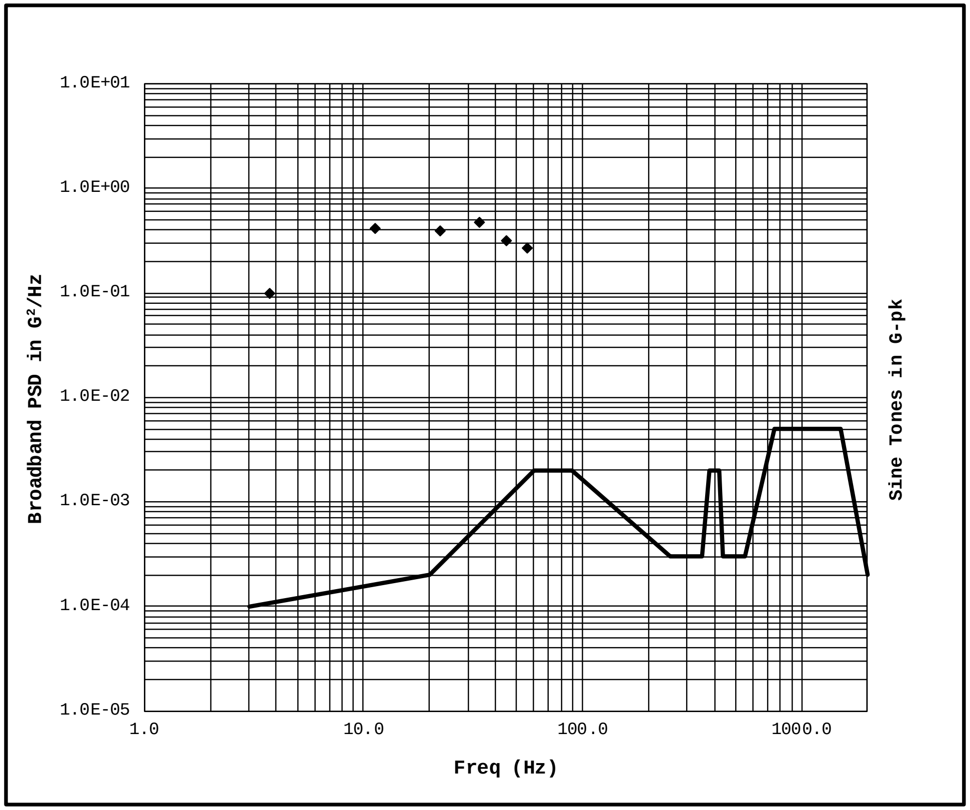
Figure C-13. CH-47F LVTS, Region: Avionics Closet; Axis: Long.

CH-47F LVTS

Aircraft Region: Avionics Closet

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	1.00E-04
20.0	2.00E-04
60.0	2.00E-03
90.0	2.00E-03
250.0	3.00E-04
350.0	3.00E-04
380.0	2.00E-03
420.0	2.00E-03
440.0	3.00E-04
550.0	3.00E-04
750.0	5.00E-03
1500.0	5.00E-03
2000.0	2.00E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.41
6P	22.50	0.39
9P	33.75	0.47
12P	45.00	0.32
15P	56.25	0.27

Broadband Info

Grms (Grms)	2.28
Max Vel (in/sec)	1.67
Max Disp (In Pk-Pk)	0.07

Sine Tone Info

Max Vel (in/sec)	2.26
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

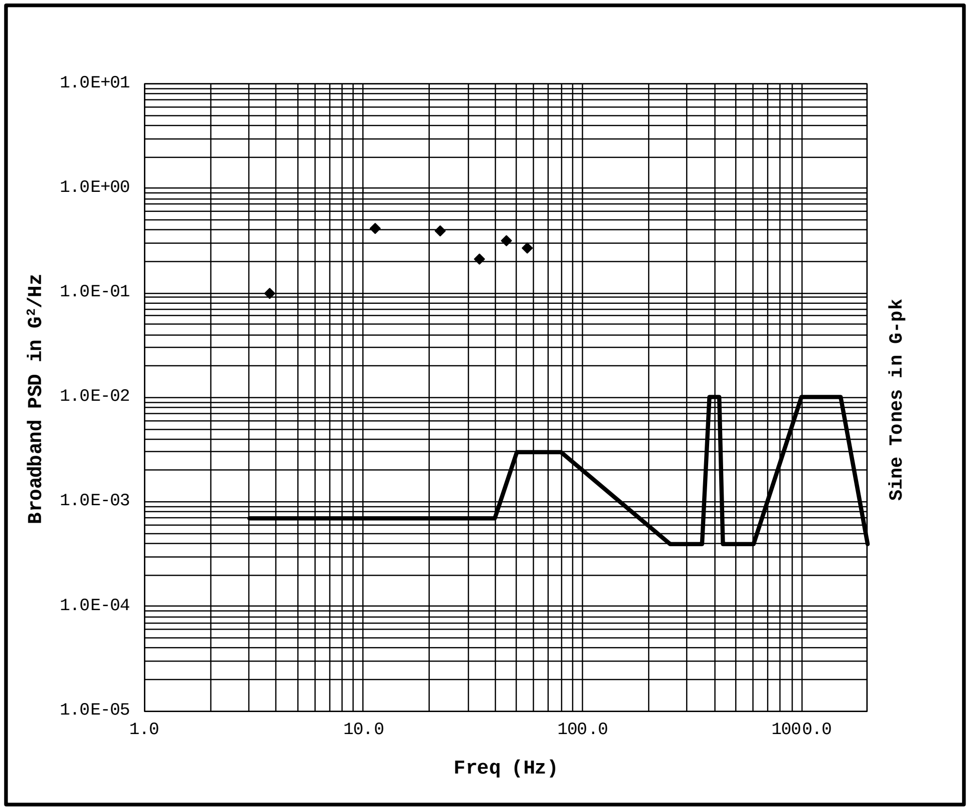
Figure C-14. CH-47F LVTS, Region: Avionics Closet; Axis: Transverse.

CH-47F LVTS

Aircraft Region: Avionics Closet

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	7.00E-04
40.0	7.00E-04
50.0	3.00E-03
80.0	3.00E-03
250.0	4.00E-04
350.0	4.00E-04
380.0	1.00E-02
420.0	1.00E-02
440.0	4.00E-04
600.0	4.00E-04
1000.0	1.00E-02
1500.0	1.00E-02
2000.0	4.00E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.41
6P	22.50	0.39
9P	33.75	0.21
12P	45.00	0.32
15P	56.25	0.27

Broadband Info

Grms (Grms)	2.95
Max Vel (in/sec)	3.02
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	2.26
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-15. CH-47F LVTS, Region: Avionics Closet; Axis: Vertical.

CH-47F LVTS

Aircraft Region: Aft Transmission

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	2.00E-04
30.0	2.00E-04
60.0	2.50E-03
150.0	2.50E-03
200.0	2.00E-02
300.0	2.00E-02
340.0	2.00E-01
420.0	2.00E-01
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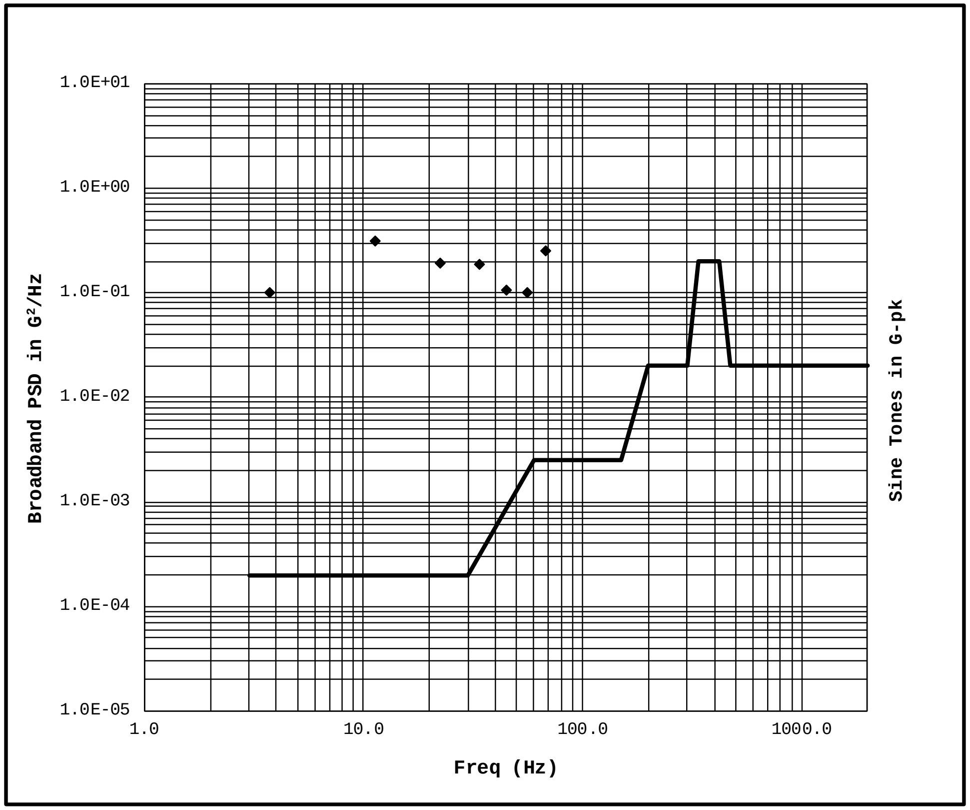
2000.0	2.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.31
6P	22.50	0.19
9P	33.75	0.19
12P	45.00	0.11
15P	56.25	0.10
18P	67.50	0.25
21P	78.75	0.23

Broadband Info

Grms (Grms)	7.51
Max Vel (in/sec)	3.40
Max Disp (In Pk-Pk)	0.09

Sine Tone Info

Max Vel (in/sec)	1.71
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

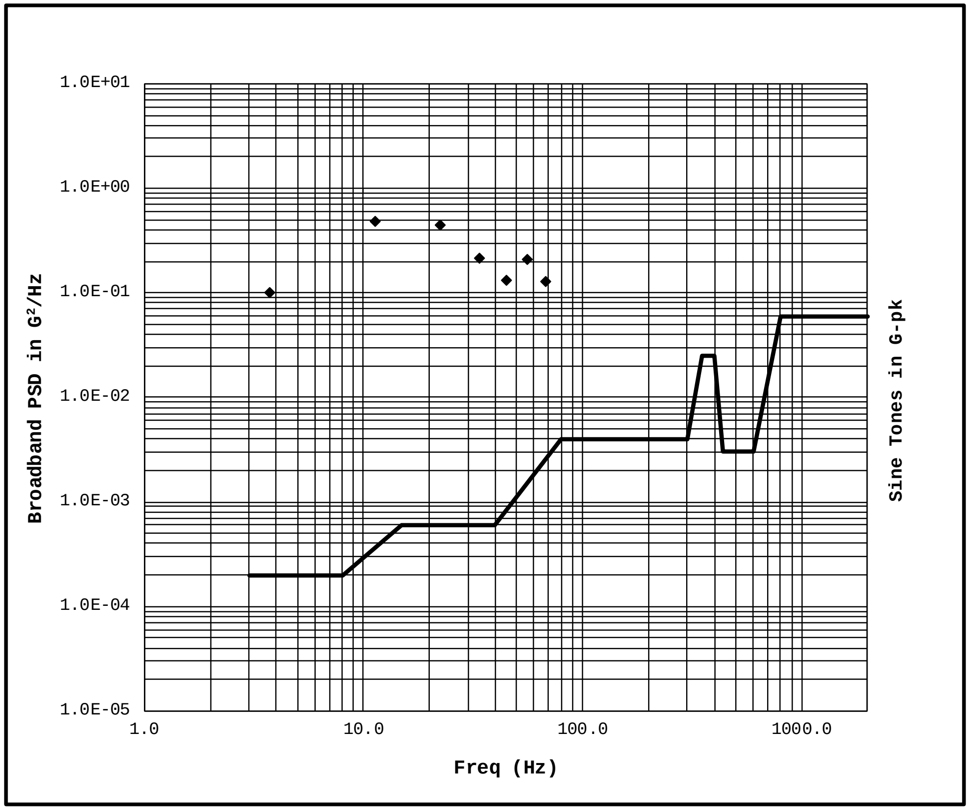
Figure C-16. CH-47F LVTS, Region: Aft Transmission; Axis: Long.

CH-47F LVTS

Aircraft Region: Aft Transmission

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	2.00E-04
8.0	2.00E-04
15.0	6.00E-04
40.0	6.00E-04
80.0	4.00E-03
300.0	4.00E-03
350.0	2.50E-02
400.0	2.50E-02
440.0	3.00E-03
600.0	3.00E-03
800.0	6.00E-02
2000.0	6.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.48
6P	22.50	0.44
9P	33.75	0.21
12P	45.00	0.13
15P	56.25	0.21
18P	67.50	0.13
21P	78.75	0.16

Broadband Info

Grms (Grms)	8.93
Max Vel (in/sec)	2.70
Max Disp (In Pk-Pk)	0.09

Sine Tone Info

Max Vel (in/sec)	2.63
Max Disp (in Pk-Pk)	0.14

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

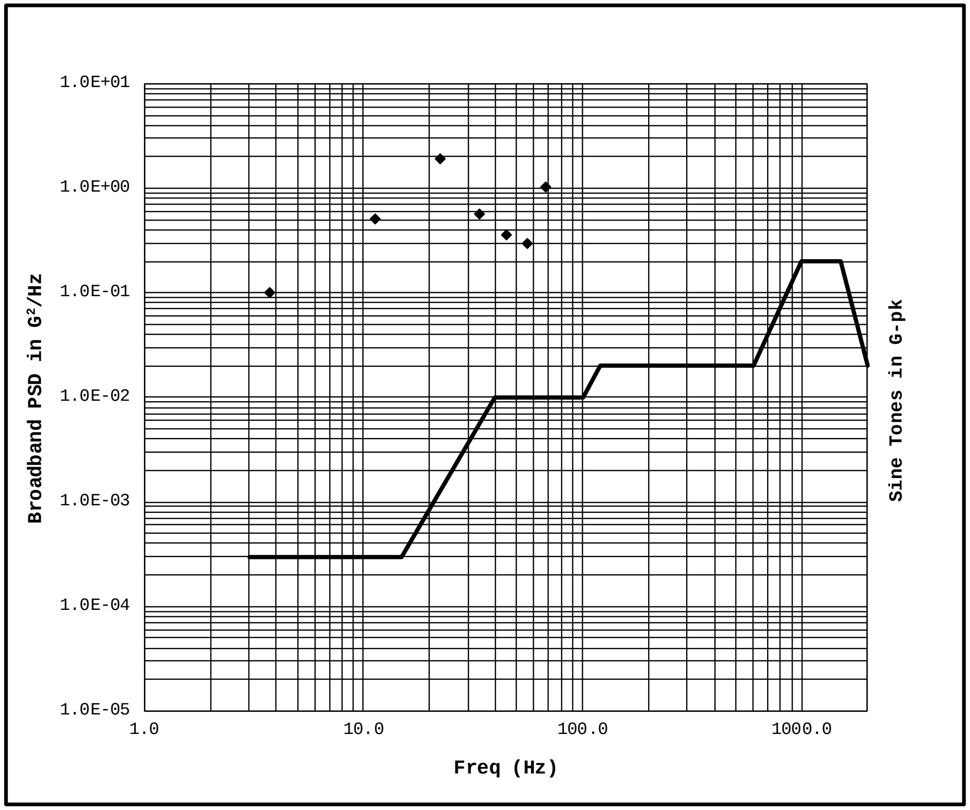
Figure C-17. CH-47F LVTS, Region: Aft Transmission; Axis: Transverse.

CH-47F LVTS

Aircraft Region: Aft Transmission

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3.0	3.00E-04
15.0	3.00E-04
40.0	1.00E-02
100.0	1.00E-02
120.0	2.00E-02
600.0	2.00E-02
1000.0	2.00E-01
1500.0	2.00E-01
2000.0	2.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.10
3P	11.25	0.51
6P	22.50	1.93
9P	33.75	0.57
12P	45.00	0.36
15P	56.25	0.30
18P	67.50	1.04
21P	78.75	0.84

Broadband Info

Grms (Grms)	13.48
Max Vel (in/sec)	4.53
Max Disp (In Pk-Pk)	0.12

Sine Tone Info

Max Vel (in/sec)	5.27
Max Disp (in Pk-Pk)	0.14

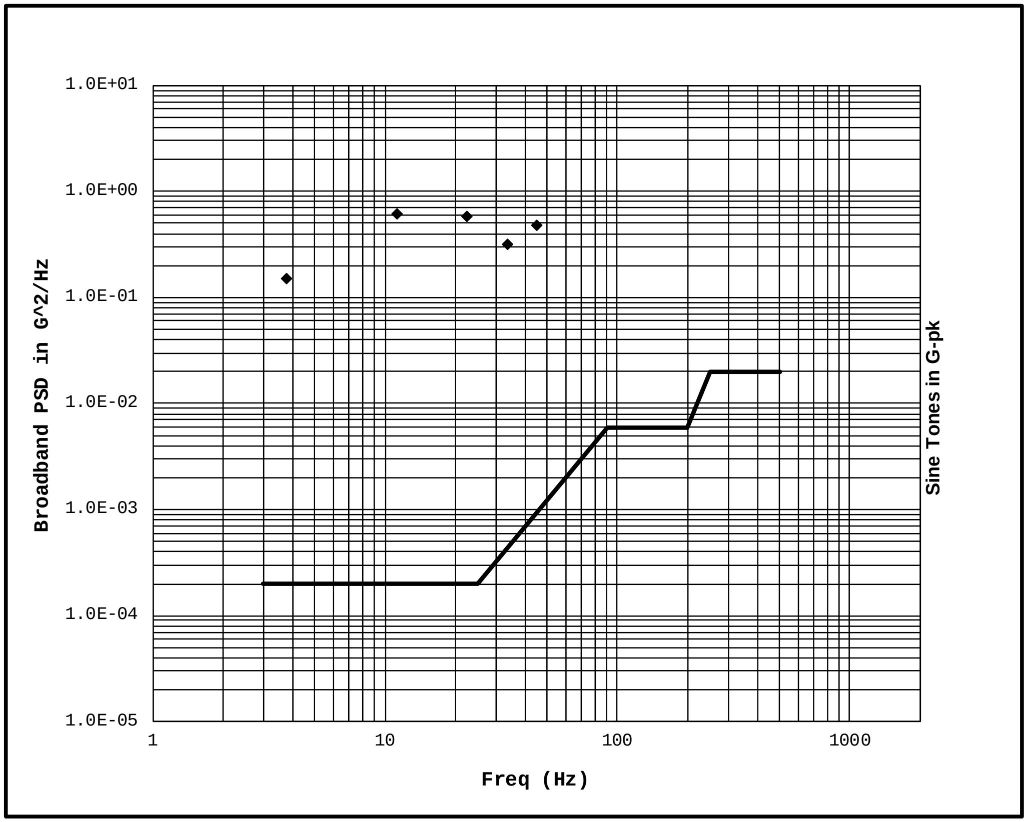
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure C-18. CH-47F LVTS, Region: Aft Transmission; Axis: Vertical.

CH-47F LVTS
Aircraft Region: External Store
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3	2.00E-04
25	2.00E-04
90	6.00E-03
200	6.00E-03
250	2.00E-02
500	2.00E-02



Sine Tones - G Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.15
3P	11.25	0.62
6P	22.50	0.58
9P	33.75	0.32
12P	45.00	0.48

Broadband Info

Grms (Grms)	2.53
Max Vel (in/sec)	2.49
ax Disp (In Pk-Pk)	0.09

Sine Tone Info

Max Vel (in/sec)	3.39
Max Disp (in Pk-Pk)	0.21

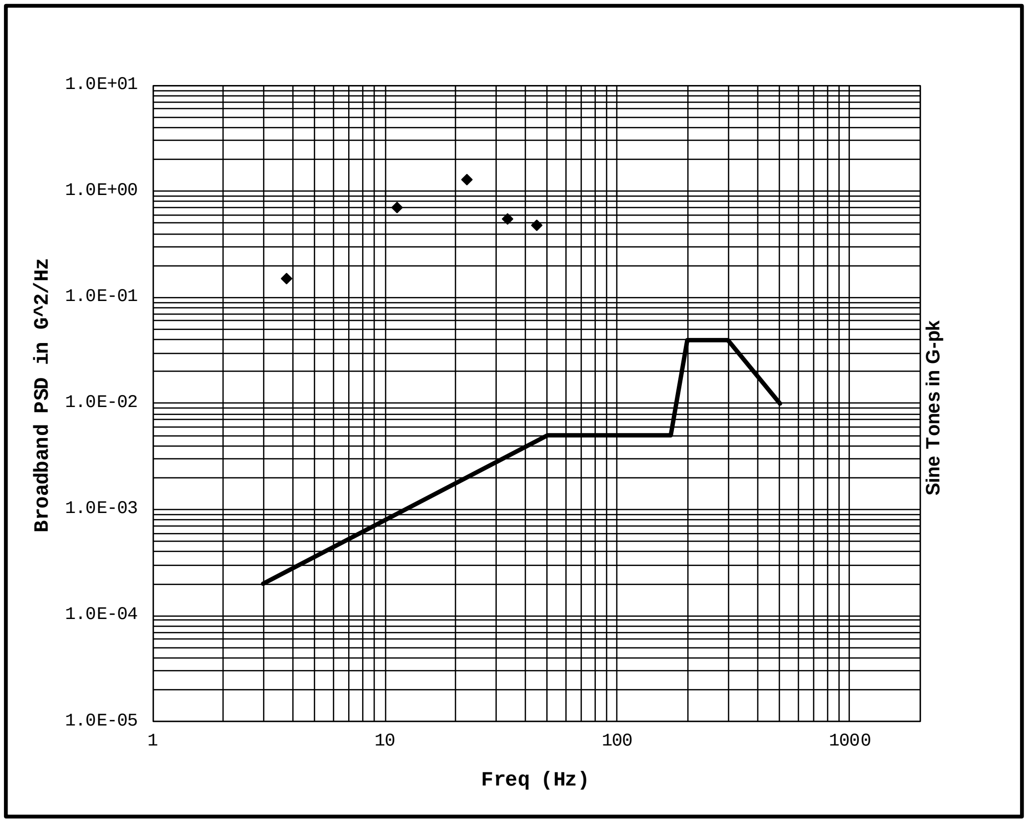
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G-CN1, Method 514.7, Section 4.2.2

Figure C-19. CH-47F LVTS, Region: External Store; Axis: Long.

CH-47F LVTS
Aircraft Region: External Store
Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3	2.00E-04
50	5.00E-03
170	5.00E-03
200	4.00E-02
300	4.00E-02
500	1.00E-02



Sine Tones - G Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.15
3P	11.25	0.71
6P	22.50	1.29
9P	33.75	0.55
12P	45.00	0.48

Broadband Info

Grms (Grms)	3.05
Max Vel (in/sec)	3.75
ax Disp (In Pk-Pk)	0.12

Sine Tone Info

Max Vel (in/sec)	3.89
Max Disp (in Pk-Pk)	0.21

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G-CN1, Method 514.7, Section 4.2.2

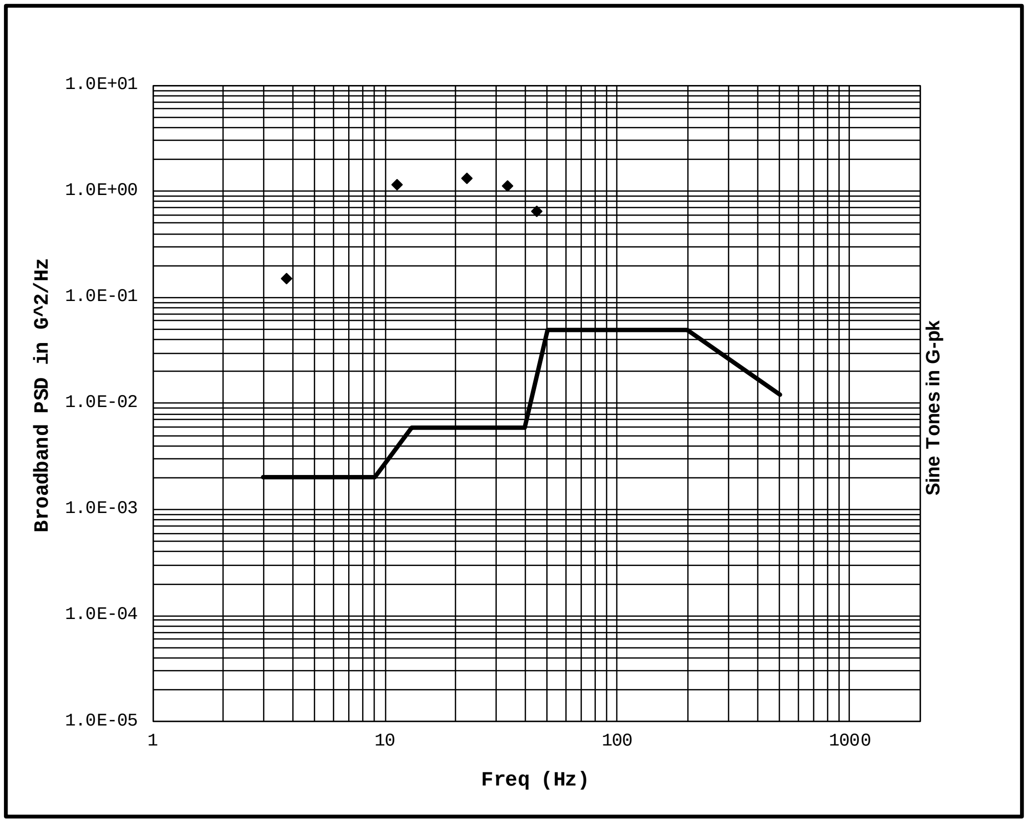
Figure C-20. CH-47F LVTS, Region: External Store; Axis: Transverse.

CH-47F LVTS
Aircraft Region: External Store
Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
3	2.00E-03
9	2.00E-03
13	6.00E-03
40	6.00E-03
50	5.00E-02
100	5.00E-02
120	5.00E-02
200	5.00E-02
500	1.20E-02

Broadband Info

Grms (Grms)	3.88
Max Vel (in/sec)	7.85
ax Disp (In Pk-Pk)	0.30



Sine Tones - G Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	3.75	0.15
3P	11.25	1.15
6P	22.50	1.35
9P	33.75	1.13
12P	45.00	0.66

Sine Tone Info

Max Vel (in/sec)	6.30
Max Disp (in Pk-Pk)	0.21

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G-CN1, Method 514.7, Section 4.2.2

Figure C-21. CH-47F LVTS, Region: External Store; Axis: Vertical.

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APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

D.1 TEST ITEM.

The test item for this VSD effort was a UH-60M, Aircraft 11-20541. The vehicle Engine Start Gross Weight (ESGW) was 16,385 lbs and the Engine Start Center of Gravity (ESCG) was 386.8 inches. Maintenance Work Orders (MWO) and Service Bulletins (SB) performed on the test aircraft are listed in Table D-1. The UH-60M (Figure D-1) is a twin turbine engine, single rotor four blade, semi-monocoque fuselage helicopter. The primary mission of the UH-60M is tactical transport of troops, supplies, and equipment. Secondary missions include training, mobilization, development of new and improved concepts, support of disaster relief, and command and control. The UH-60M is equipped with composite spar wide-cord main rotor blades that provide 500 pounds more lift than the current UH-60L blades. Additionally, the new General Electric T700-GE-701D engines produce slightly more shaft horsepower, allowing 500 pounds of additional payload. The UH-60M features a Rockwell Collins glass cockpit with a narrower instrument panel to improve chin window visibility. The UH-60M new cabin and transition section use high-speed machine frames, reducing the cost and complexity of the cabin. Dual digital flight controls and fully-coupled flight directors are installed to reduce pilot workload. Altitude and hover hold help to avoid “white-out” and “brown-out” mishaps, while active vibration control reduces pilot fatigue encountered in lengthy missions. On-board diagnostics isolate problems and allow precise system diagnosis, and an Improved Hover Infrared Suppression System provides superior battlefield protection from infrared weapons.

Figure D-1. UH-60M Blackhawk Helicopter.

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

TABLE D-1. UH-60M AIRCRAFT 11-20541 MWO AND SB

MWO OR SB NUMBER	SHORT TITLE
1-1520-237-50-90	ENGINE INLET BARRIER FILTER AND APU INLET FILTER

D.2 SUPPORTING DATA ANALYSIS SOFTWARE.

The software tools used to derive the LVTS in this document were developed IAW the guidelines of MIL-STD-810G CN1 Method 514.7 Annex F, and NATO STANAG 4370 Leaflet 2410. Calibration of the individual test equipment associated with the data acquisition was performed through the U.S. Army's Test, Measurement, and Diagnostic Equipment Program or via subcontract to accredited calibration laboratories. Calibration was performed IAW the original manufacturer's established standards and procedures for original equipment performance, with standard test equipment and laboratory standards traceable to the NIST. The validity of equipment calibration was verified prior to test.

D.3 TEST OBJECTIVE.

The objective of the test was to develop new LVTS for the UH-60M platform to replace outdated vibration test levels presented in MIL-STD-810G CN1. The testing effort was completed in two phases.

a. Collected vibration data at locations of interest on the UH-60M during flight testing. Flight testing encompassed maneuvers that provided a good representation of the Mission Scenario.

b. Utilized flight test data to develop vibration specifications for the UH-60M.

D.4 DETAILS OF FLIGHT TEST.

D.4.1 Flight Maneuvers.

An effort was made to hold each test point for a minimum of 30 seconds in order to provide optimal statistical averaging for PSD calculations; however, due to the inherent nature of some of the test points, this was not possible for all test maneuvers. Overlap processing was employed to maximize the number of averages in the PSD calculations.

D.4.2 Instrumentation.

Instrumentation locations on the UH-60M were selected in an effort to capture the overall vibration levels on the aircraft. Due to programmatic constraints for this effort, instrumentation

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

was limited to 20 triaxial accelerometers. A detailed list of instrumentation locations can be found in Table D-2 and Figure D-2. Observe that the filter cutoff frequency (Fc) was raised to 2170 Hz for accelerometer locations in the engine and transmission locations as higher frequency response was anticipated. A posttest review of the data showed issues with the data taken at the Tail Rotor Gear Box location. Data collected from this location were not included in the original LVTS. Refer to paragraph D.4.3 regarding the alternate reference dataset associated with the Vertical Tail Pylon vibration test schedules. A list of aircraft parameters measured is provided in Table D-3.

TABLE D-2. UH-60M INSTRUMENTATION LOCATIONS

ACCEL NUMBER	LOCATION DESCRIPTION	RANGE (g)	SAMPLE RATE (SPS)	Fc (Hz)
VIB 1	Nose mount	±20	8680	1085
VIB 2	Floor (pedals) Left	±20	8680	1085
VIB 3	Floor (pedals) Right	±20	8680	1085
VIB 4	Pedal Adjust Left	±20	8680	1085
VIB 5	Center Console	±20	8680	1085
VIB 6	Cockpit 250 beam left	±20	8680	1085
VIB 7	Cockpit 250 beam Right	±20	8680	1085
VIB 8	Aft ESSS mount high left	±20	8680	1085
VIB 9	Aft ESSS mount high right	±20	8680	1085
VIB 10	ESSS mount low right	±20	8680	1085
VIB 11	Main Transmission Mount front	±50	8680	2170
VIB 12	Main Transmission Mount aft	±50	8680	2170
VIB 13	398 Beam Right mid	±20	8680	1085
VIB 14	ALQ-144 Mount	±50	8680	2170
VIB 15	Aft AVX Comp Bulkhead	±20	8680	1085
VIB 16	Aft Stringer	±20	8680	1085
VIB 17	Aft AVX rack mid	±20	8680	1085
VIB 18	Drive Shaft Damper	±50	8680	2170
VIB 19	Intermediate G/B	±50	8680	2170
VIB 20	Tail Rotor G/B	±50	8680	2170
A-1	Aft Tail – Upper (Alternate Data Set)	±20	3086	771
A-2	Aft Tail – Lower (Alternate Data Set)	±20	3086	771

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

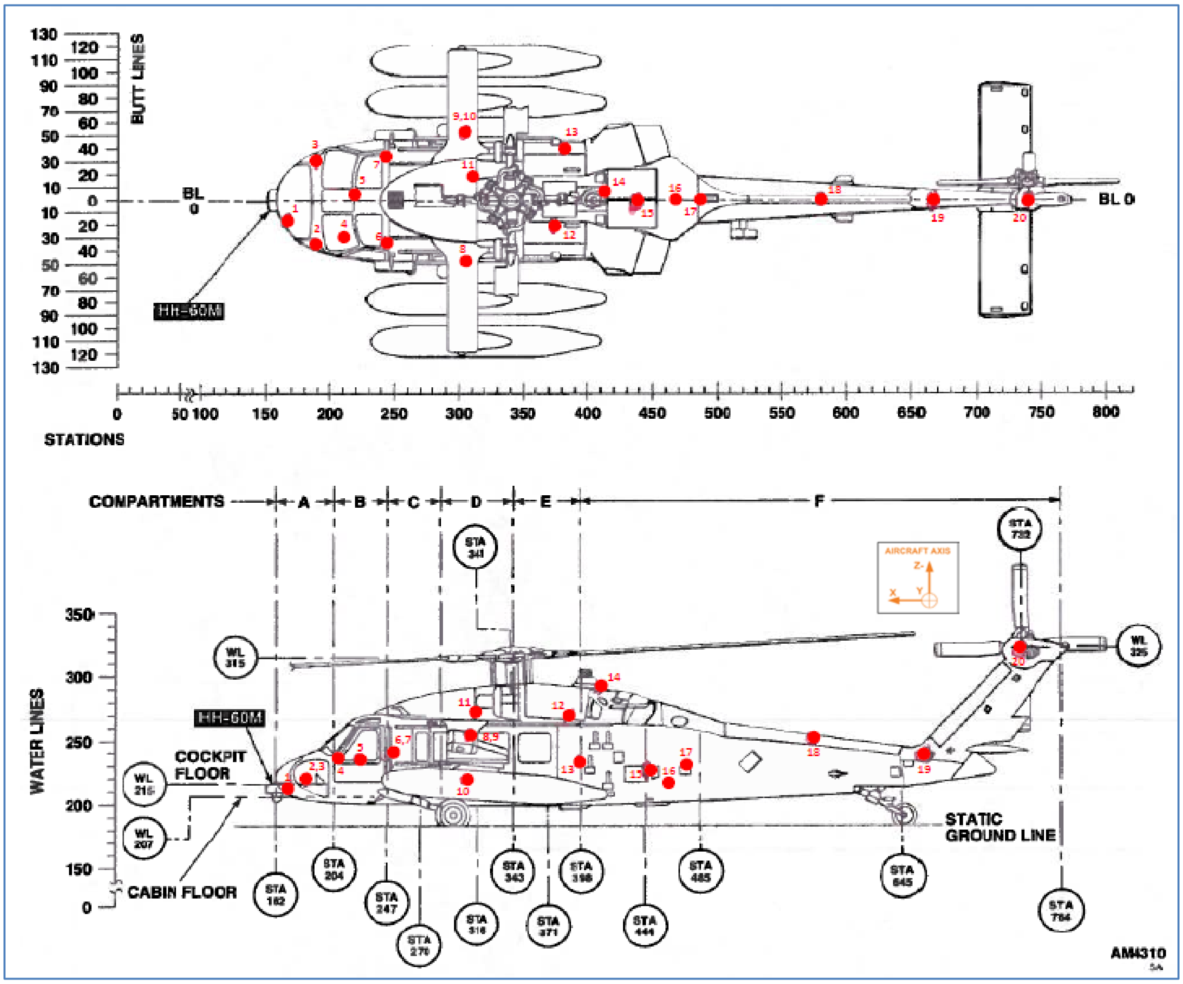


Figure D-2. Accelerometer locations.

TABLE D-3. UH-60M BUS PARAMETER LIST

MNEMONIC	DESCRIPTION	UNITS	SPS
EGI1GPSLAT	LATITUDE	Radians	20
EGI1GPSLONG	LONGITUDE	Radians	20
EGI1EGRALT	ALTITUDE	Feet	20
EGI1AS	AIRSPEED	Knots	20
EGI1ROLLANGLE	ROLL ANGLE	Degrees	20
EGI1PITCHANGLE	PITCH ANGLE	Degrees	20
EGI1HEAD	HEADING	Degrees	20
EGI1ROLLRATE	ROLL RATE	Degrees/Sec	20
EGI1PITCHRATE	PITCH RATE	Degrees/Sec	20
EGI1YAWRATE	YAW RATE	Degrees/Sec	20

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

D.4.3 Flight Test.

a. The RTC conducted flight testing on UH-60M Aircraft 11-20541 on 23-24 June 2014 for the purpose of collecting aircraft vibration data. Vibration data were recorded at the locations shown in Table D-2. Table D-3 shows aircraft bus parameters that were recorded during testing.

b. Instrumentation issues resulted in insufficient data to develop LVTS for the Vertical Tail Pylon region. An alternate UH-60 dataset (see Appendix E Reference 4) was identified with sufficient data and utilized for this purpose. Instrumentation locations for the alternate dataset are identified as A-1 and A-2 in Table D-2. The alternate test was conducted with a UH-60A. Test conduct and flight maneuvers were similar for both test efforts.

D.5 DETAILS OF VIBRATION SPECIFIC DEVELOPMENT.

D.5.1 Methodology.

The techniques in the code employed to compute the subject LVTS's are in accordance with the recommendations of MIL-STD-810G-CN1 Method 514.7, Annex F. Copies of all field data and UH-60M specific macros were saved and filed.

D.5.2 Mission Scenario.

The flight maneuvers flown during flight testing were chosen to provide a representation of the expected UH-60M usage spectrum. These flight maneuvers were each assigned a percentage value that correlates the flight maneuver to the total expected exposure over the lifecycle of the test article. The LVTSs were developed to be equivalent to a total of 2500 flight hours on the UH- 60M platform. The lifecycle scenario was developed from The UH-60M Flight Usage Spectrum detailed in Table D-3 of AVNS-PRF-10002H, Performance Specification System Specification for the UH-60M Black Hawk Utility Helicopter[5] and discussions with Military Pilots. The lifecycle scenario utilized in the LVTS development can be found in Table D-4. Factors such as airspeed and angle of bank were verified per the 1553 bus parameters as listed in Table D-3.

TABLE D-4. UH-60M MISSION SCENARIO

MANEUVER DESCRIPTION	SCENARIO TIME
VMC Take Off	5.81%
VMC Approach	2.85%
Level Flight 80 Kts .5Vh	6.84%
Level Flight 100 Kts .6Vh	4.70%
Level Flight 120 Kts .8Vh	22.23%
Level Flight Vh (approx 158 Kts)	38.49%

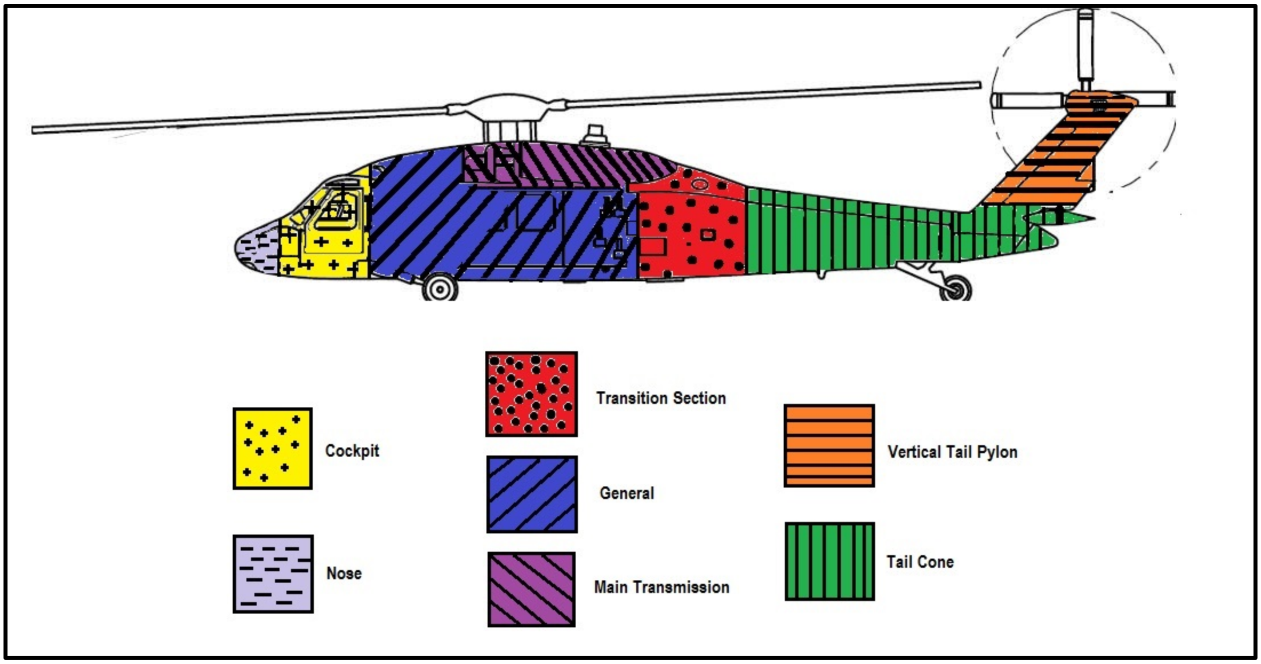
APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

MANEUVER DESCRIPTION	SCENARIO TIME
Right Turn 78 Kts 30 Deg AOB	0.66%
Right Turn 78 Kts 60 Deg AOB	0.21%
Right Turn 100 Kts 30 Deg AOB	0.66%
Right Turn 100 Kts 60 Deg AOB	0.21%
Right Turn 120 Kts 30 Deg AOB	0.66%
Right Turn 120 Kts 60 Deg AOB	0.21%
Left Turn 120 Kts 30 Deg AOB	0.66%
Left Turn 120 Kts 60 Deg AOB	0.21%
Left Turn 100 Kts 30 Deg AOB	0.66%
Left Turn 100 Kts 60 Deg AOB	0.21%
Left Turn 78 Kts 30 Deg AOB	0.66%
Left Turn 78 Kts 60 Deg AOB	0.21%
Right Climbing Turn 80 Kts, 30 Deg AOB	0.66%
Left Climbing Turn 80 Kts, 30 Deg AOB	0.66%
Right Climbing Turn 100 Kts, 30 Deg AOB	0.66%
Left Climbing Turn 100 Kts, 30 Deg AOB	0.66%
Right Climbing Turn 120 Kts, 30 Deg AOB	0.66%
Left Climbing Turn 120 Kts, 30 Deg AOB	0.66%
Autorotation 80 Kts	1.49%
Ground Run 100%Nr	0.50%
IGE Hover at 10'	0.98%
OGE Hover at 100'	0.98%
AGL 20ft 10 Kts Rel. Azi 0 Deg .06Vh	1.28%
AGL 20ft 20 Kts Rel. Azi 0 Deg .12 Vh	1.28%
AGL 20ft 30 Kts Rel. Azi 0 Deg .19Vh	0.86%
AGL 20ft 40 Kts Rel. Azi 0 Deg 0.25Vh	0.86%
AGL 20ft 10 Kts Rel. Azi 90 Deg	0.14%
AGL 20ft 20 Kts Rel. Azi 90 Deg	0.14%
AGL 20ft 30 Kts Rel. Azi 90 Deg	0.14%
AGL 20ft 40 Kts Rel. Azi 90 Deg	0.14%
AGL 20ft 10 Kts Rel. Azi 180 Deg	0.14%
AGL 20ft 20 Kts Rel. Azi 180 Deg	0.14%
AGL 20ft 30 Kts Rel. Azi 180 Deg	0.14%
AGL 20ft 40 Kts Rel. Azi 180 Deg	0.14%
AGL 20ft 10 Kts Rel. Azi 270 Deg	0.14%
AGL 20ft 20 Kts Rel. Azi 270 Deg	0.14%
AGL 20ft 30 Kts Rel. Azi 270 Deg	0.14%
AGL 20ft 40 Kts Rel. Azi 270 Deg	0.14%
TOTAL:	**100%**

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

D.5.3 Location Groupings.

In the VSD process a determination must be made as to when and where to group data locations together in producing LVTSs for specific regions of the aircraft. Data collection points were grouped together in the VSD process as shown in Figure D-3 and Table D-5. The final vibration specification was developed by taking a spectral line by spectral line maxi of the test levels for each group on a per axis basis.



Note: Regions shown are for general guidance only and are not intended to provide definitive profile selection.

Figure D-3. Aircraft regions.

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

TABLE D-5. ACCELEROMETER VSD GROUPINGS

AIRCRAFT REGION	ACCEL NUMBER	DATA POINT LOCATION	STATION (INCHES)	WATER LINE (INCHES)	BUTT LINE (INCHES)
Nose	VIB 1	Nose Mount	168	212	-10
	VIB 2	Floor (Pedals) Left	186	215	-29
	VIB 3	Floor (Pedals) Right	186	215	+29
Cockpit	VIB 4	Pedal Adjust Left	198	240	-25
	VIB 5	Center Console	231	229	+4
	VIB 6	Cockpit 250 Beam Left	247	240	-40
	VIB 7	Cockpit 250 Beam Right	247	240	+40
General	VIB 6	Cockpit 250 Beam Left	247	240	-40
	VIB 7	Cockpit 250 Beam Right	247	240	+40
	VIB 8	Aft ESSS Mount High Left	307	260	-51
	VIB 9	Aft ESSS Mount High Right	307	260	+51
	VIB 10	ESSS Mount Low Right	308	217	+48
	VIB 13	398 Beam Right Mid	398	248	+42
Transition Section	VIB 15	Aft AVX Comp Bulkhead	444	203	-6
	VIB 16	Aft Stringer	455	203	-11
	VIB 17	Aft AVX Rack Mid	485	230	+15
Main Transmission	VIB 11	Main Transmission Mount Front	327	265	+10
	VIB 12	Main Transmission Mount Aft	357	267	-9
	VIB 14	ALQ-144 Mount	412	276	+9
Tail Cone	VIB 18	Drive Shaft Damper	575	250	0
Vertical Tail Pylon	A-1	Aft Tail – Upper (Alternate Data Set)	Not Available		
	A-2	Aft Tail – Lower (Alternate Data Set)	Not Available		
External Stores	Insufficient data were available to develop LVTS for this region. The LVTS provided were derived by applying scaling factors to the General LVTS. The scaling factors (1.5 for sine tones, 2 for broadband breakpoints) were based on the ration of the External Stores and General profiles in MIL-STD-810G-CN1				
On/Near Drive System Elements	Refer to Table 1 Defaults.				

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

D.5.4 VSD Results.

a. The spectral content of the vibration energy for the locations of interest on the UH-60M was SOR in nature. The sine portion of the vibration energy was primarily driven by the main rotors of the UH-60M. The frequency of the dominant sinusoidal content was constant and driven by the nominal rotor passage frequency of 4.3 Hz. The nature of the vibration data dictated the development of a SOR laboratory vibration test with stationary sinusoidal tones.

b. All reference levels in this Appendix were compared to the measured field levels to ensure acceptable ratios between the final specifications and maximum measured levels were met per the guidance in MIL-STD-810G/CN1 ANNEX F. This criteria was met while maintaining a specified test duration of 4.0 hours (representing 2500 hours of flight) which was consistent with previous MIL-STD-810 default helicopter vibration specification test durations. Should the default test times be modified, refer to the guidance in Section 6 of the body of this TOP.

c. LVTSs were produced for each of the three mutually orthogonal translational axes (x-axis or longitudinal with respect to the aircraft, y-axis or translational to the aircraft, and z-axis or vertical with respect to the aircraft). For a complete 2500 flight hour laboratory lifecycle vibration replication, the test item should be subjected to all three LVTS axes.

d. Care should be taken when selecting a test profile from the default profiles provided to ensure it is appropriate for use for the article under test. Consider the planned deployment location of the test article on the UH-60M and select the default LVTS in the associated zone of interest. When it is unclear which of the default profiles should be utilized for a test item the General LVTS should be selected. For test articles where aircraft orientation may be unknown or not fixed, it is recommended that each axis of the test article be tested to the envelope of all possible axes of aircraft orientation for that test article. For example, for cargo in which placement relative to the aircraft orientation between x and y are unknown, it is recommended that both x and y axes of the cargo be tested to the envelope of the longitudinal and transverse LVTS for the zone of interest.

D.5.5 Functional Test Considerations.

In the calculation of the sine reference levels, a conservatism factor of 1.2 was applied to the sine tones to account for unknowns and the fact that only a single vehicle was employed in acquisition of the field data from which the LVTSs were derived. In addition, Miner-Palmgern techniques were employed to compress the test duration to 4 hours per axis as discussed above. The resulting ratio of LVTS reference levels to maximum measured levels will vary across tones for each frequency of interest. This eliminates the ability to define a constant level for reducing Endurance vibration levels to Functional vibration levels while maintaining a direct fatigue equivalence. The trends in the ratios of final specification to maximum measured field data for the UH-60M LVTS development were reviewed. Based on this review, a reduction of 4.5 dB

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

from the LVTSs provided in this Appendix will yield laboratory levels comparable to maximum measured field data (conservatism included) and is recommended for implementation of Functional testing. Test time associated with Functional testing should be kept to a minimum and is generally not considered as part of the Endurance test duration.

D.5.6 Reliability Test Considerations.

a. The LVTSs as published in this TOP have been compressed to provide the equivalent of 2500 hours of flight in four hours of runtime per axis. For reliability testing it is sometimes desired to operate a test item for hundreds of hours in an environment “representative” of actual exposure (i.e., uncompressed vibration). Testing at the levels recommended for functional testing is not appropriate as that would be the equivalent of running at near maximum levels for the full duration.

b. In the process of establishing reference criteria for a reliability test, while backing out sufficient compression to yield representative field levels, it is desired to maintain a reasonable fatigue equivalency. Dealing with uncompressed 1-DOF references, laboratory run time will be 3:1 longer than the actual equivalent flight time. If one applies Miner-Palmgren techniques using the exponent associated with sinusoidal excitation (m=6.43) and assuming 1/3 of the 2500 flight hours (833 hours) of laboratory time per axis, the published references would be run at -7.21 dB. The resulting 2500 hours of laboratory run time would represent 2500 hours of flight in this case. Realizing that the exponent in Miner-Palmgren differs for sine and random signals and understanding the proposed levels for a reliability test are being defined while maintaining reasonable fatigue equivalency it is recommended that a 7 dB reduction at a duration of 833 hrs/axis (representing 2500 hours) be employed as a basis. Any reliability test to be conducted at an arbitrary number of desired hours may be computed by simply linearly scaling time. For example, if one desired to conduct a reliability test for 1500 hours, the published specs would be executed at -7 dB and the duration per axis would be 500 hrs.

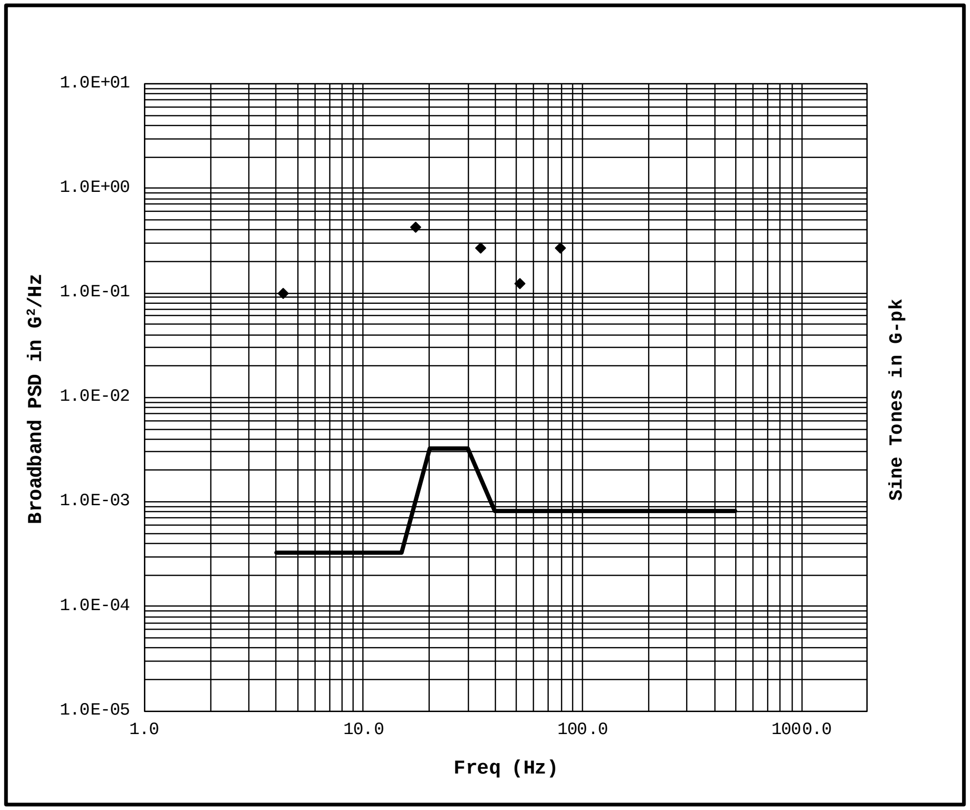
D.6 SUMMARY OF RESULTS.

LVTSs for the UH-60M Blackhawk platform were developed and are included in Figures D-4 through D-27. In the event LVTSs are required for other variants of the UH-60, the ideal solution would be to develop them based on measured field data. In the absence of such data, the schedules provided in this document may serve as an alternative. Sine tone frequencies may require slight modification if the rotor head frequency of the variant is other than 258 RPM (Nr=4.3 Hz), as in the case of the UH-60M used in this LVTS development.

APPENDIX D. UH-60M LABORATORY VIBRATION TEST SCHEDULES.

UH-60M LVTS
Aircraft Region: Nose
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-04
15.0	3.26E-04
20.0	3.26E-03
30.0	3.26E-03
40.0	8.15E-04
500.0	8.15E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.42
8P	34.4	0.27
12P	51.6	0.12
4T	79.2	0.27

Broadband Info

Grms (Grms)	0.66
Max Vel (in/sec)	2.39
Max Disp (In Pk-Pk)	0.08

Sine Tone Info

Max Vel (in/sec)	1.50
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

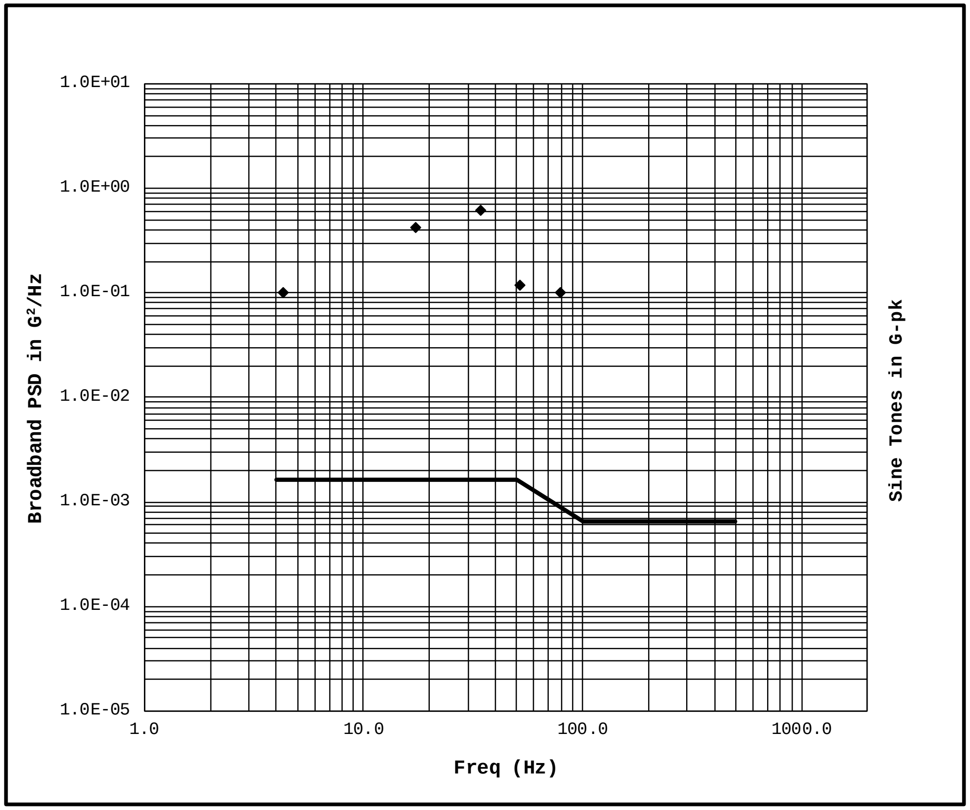
Figure D-4. UH-60M LVTS, Region: Nose; Axis: Long.

UH-60M LVTS

Aircraft Region: Nose

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
50.0	1.63E-03
100.0	6.52E-04
500.0	6.52E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.42
8P	34.4	0.61
12P	51.6	0.12
4T	79.2	0.10

Broadband Info

Grms (Grms)	0.62
Max Vel (in/sec)	3.65
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	1.49
Max Disp (in Pk-Pk)	0.11

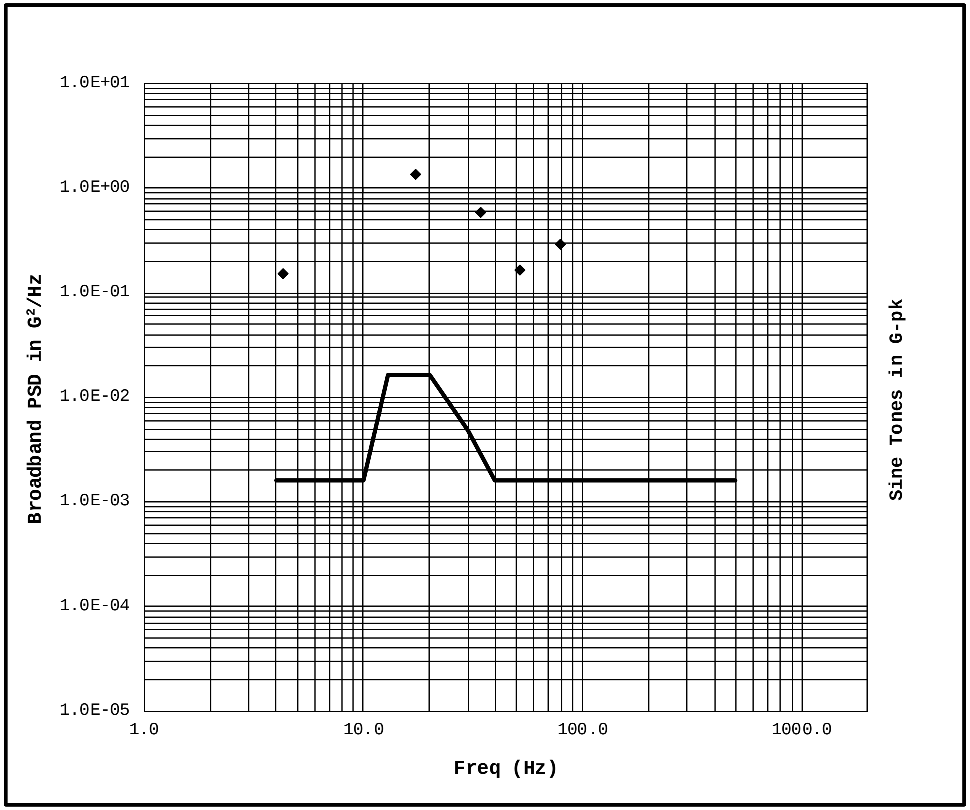
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-5. UH-60M LVTS, Region: Nose; Axis: Transverse.

UH-60M LVTS
Aircraft Region: Nose
Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
10.0	1.63E-03
13.0	1.63E-02
20.0	1.63E-02
30.0	4.89E-03
40.0	1.63E-03
500.0	1.63E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.15
4P	17.2	1.36
8P	34.4	0.58
12P	51.6	0.16
4T	79.2	0.29

Broadband Info

Grms (Grms)	1.01
Max Vel (in/sec)	5.97
Max Disp (In Pk-Pk)	0.20

Sine Tone Info

Max Vel (in/sec)	4.86
Max Disp (in Pk-Pk)	0.16

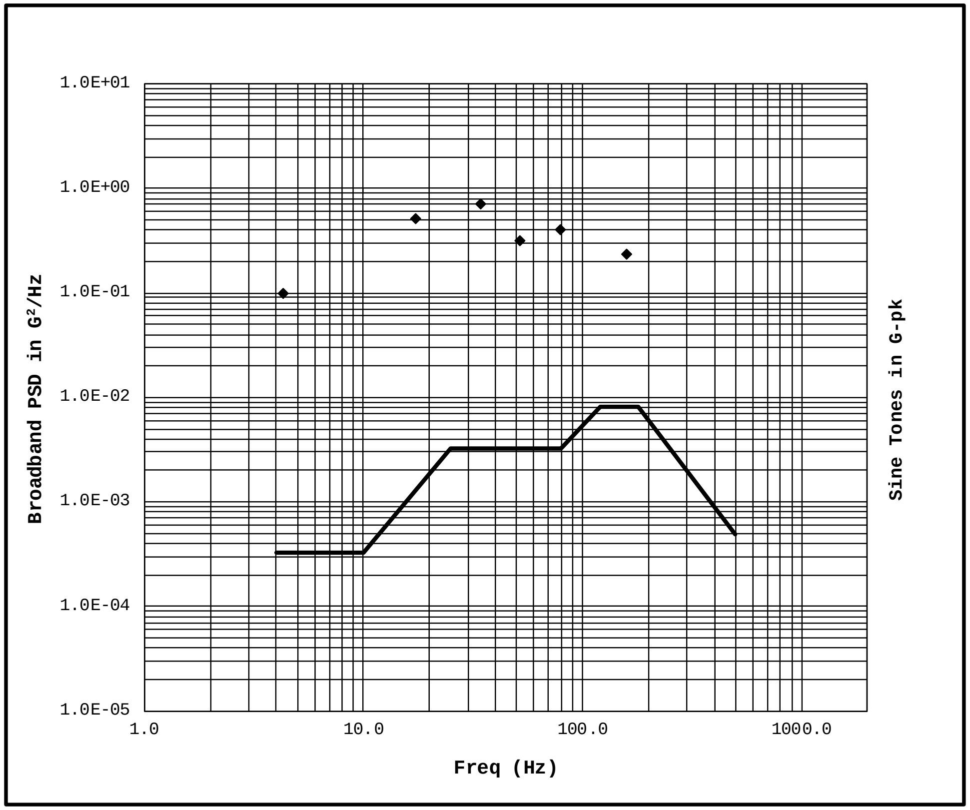
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-6. UH-60M LVTS, Region: Nose; Axis: Vertical.

UH-60M LVTS
Aircraft Region: Cockpit
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-04
10.0	3.26E-04
25.0	3.26E-03
80.0	3.26E-03
120.0	8.15E-03
180.0	8.15E-03
500.0	4.89E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.51
8P	34.4	0.72
12P	51.6	0.32
4T	79.2	0.40
8T	158.4	0.23

Broadband Info

Grms (Grms)	1.27
Max Vel (in/sec)	2.97
Max Disp (In Pk-Pk)	0.08

Sine Tone Info

Max Vel (in/sec)	1.82
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

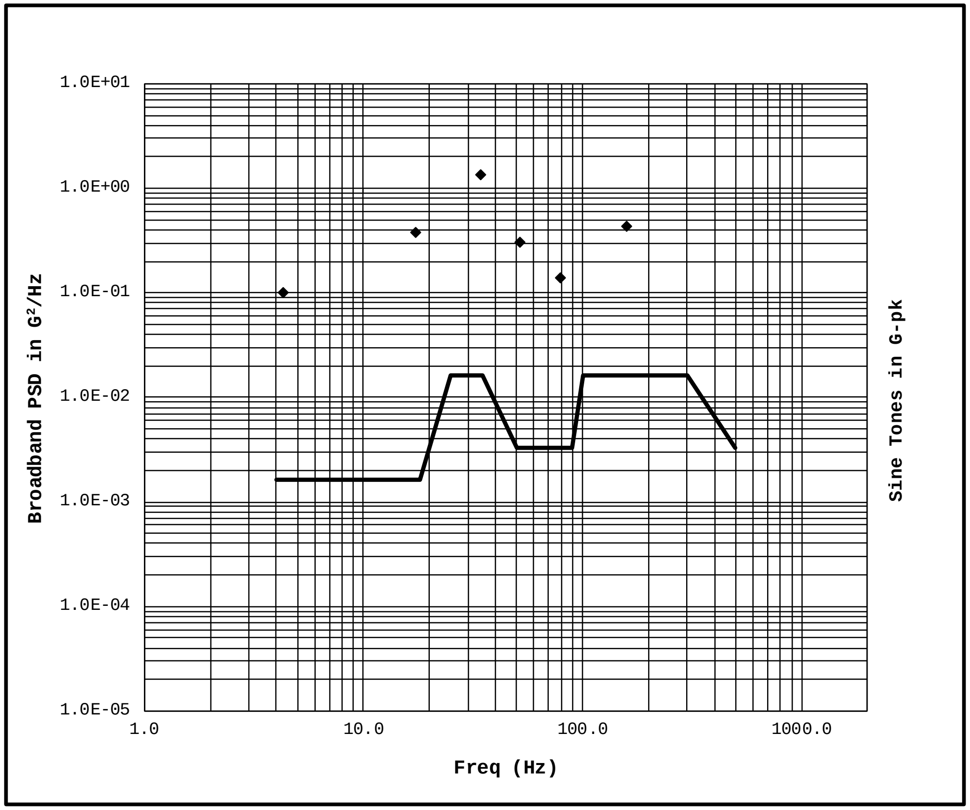
Figure D-7. UH-60M LVTS, Region: Cockpit; Axis: Long.

UH-60M LVTS
Aircraft Region: Cockpit
Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
18.0	1.63E-03
25.0	1.63E-02
35.0	1.63E-02
50.0	3.26E-03
90.0	3.26E-03
100.0	1.63E-02
300.0	1.63E-02
500.0	3.26E-03

Broadband Info

Grms (Grms)	2.31
Max Vel (in/sec)	5.30
Max Disp (In Pk-Pk)	0.17



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.38
8P	34.4	1.33
12P	51.6	0.30
4T	79.2	0.14
8T	158.4	0.43

Sine Tone Info

Max Vel (in/sec)	2.38
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

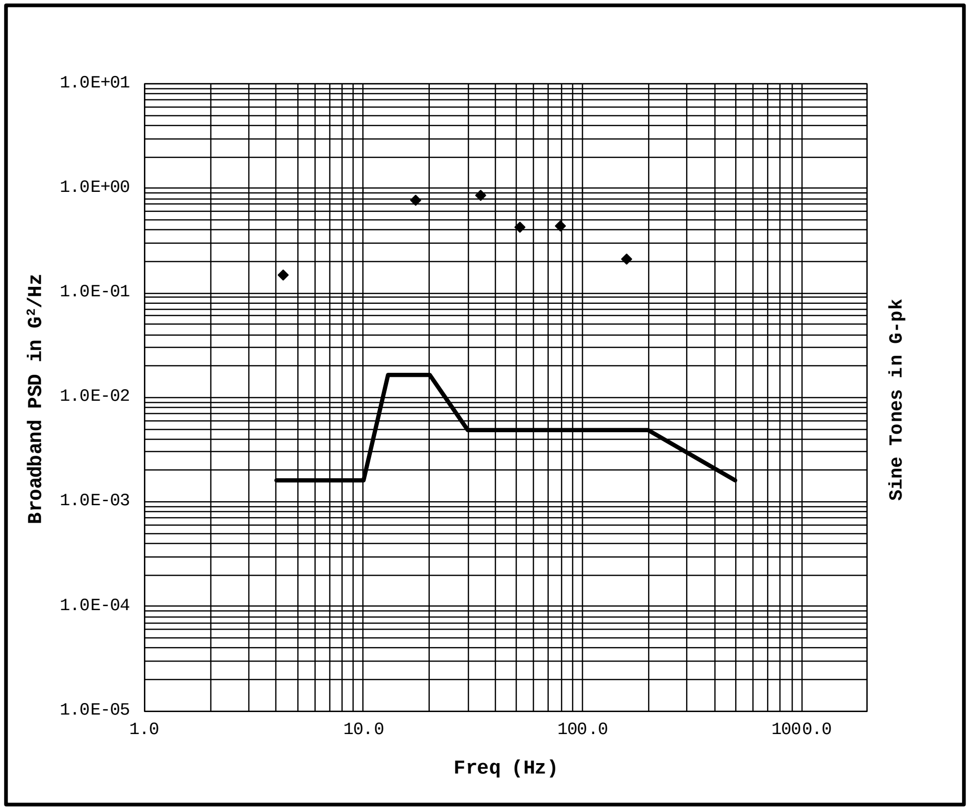
Figure D-8. UH-60M LVTS, Region: Cockpit; Axis: Transverse.

UH-60M LVTS

Aircraft Region: Cockpit

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
10.0	1.63E-03
13.0	1.63E-02
20.0	1.63E-02
30.0	4.89E-03
200.0	4.89E-03
500.0	1.63E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.15
4P	17.2	0.77
8P	34.4	0.86
12P	51.6	0.42
4T	79.2	0.43
8T	158.4	0.21

Broadband Info

Grms (Grms)	1.37
Max Vel (in/sec)	6.21
Max Disp (In Pk-Pk)	0.20

Sine Tone Info

Max Vel (in/sec)	2.76
Max Disp (in Pk-Pk)	0.16

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

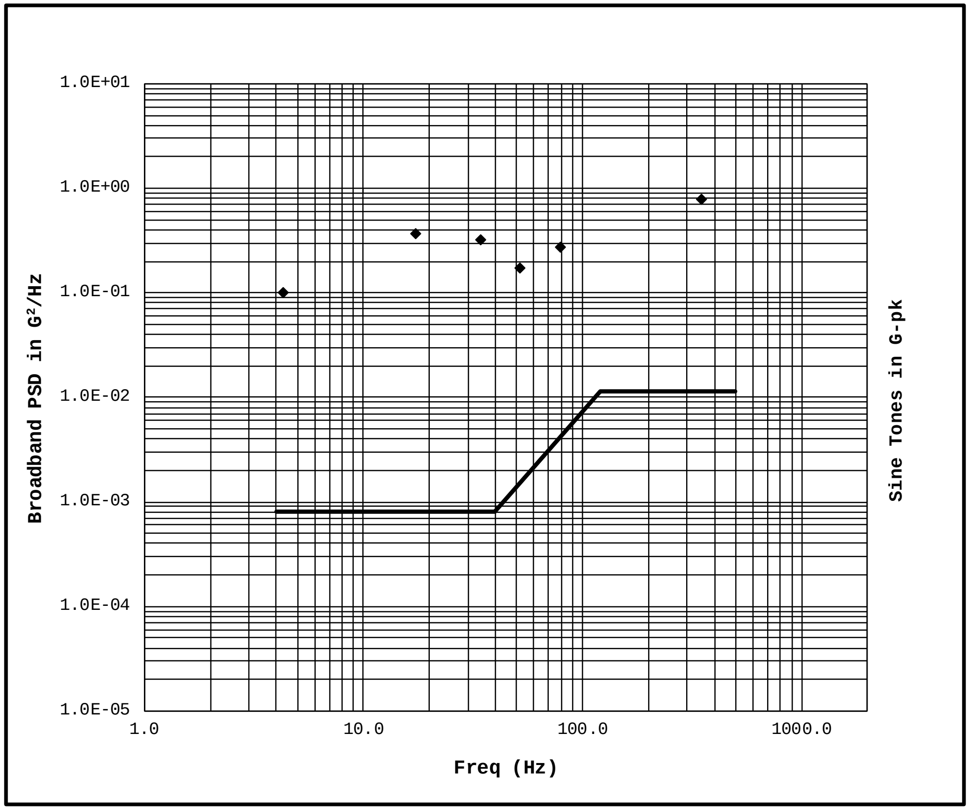
Figure D-9. UH-60M LVTS, Region: Cockpit; Axis: Vertical.

UH-60M LVTS

Aircraft Region: General

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	8.15E-04
40.0	8.15E-04
120.0	1.14E-02
500.0	1.14E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.37
8P	34.4	0.32
12P	51.6	0.17
4T	79.2	0.27
HSS	348.0	0.78

HSS: High Speed Shaft

Broadband Info

Grms (Grms)	2.18
Max Vel (in/sec)	3.24
Max Disp (In Pk-Pk)	0.12

Sine Tone Info

Max Vel (in/sec)	1.43
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

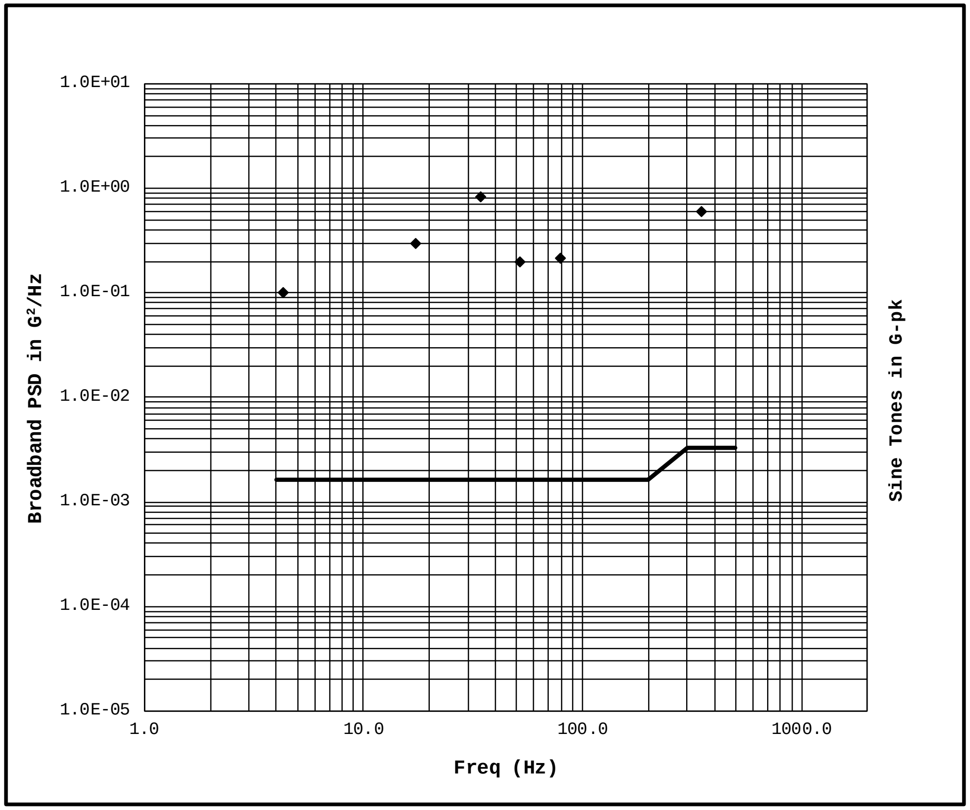
Figure D-10. UH-60M LVTS, Region: General; Axis: Long.

UH-60M LVTS

Aircraft Region: General

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
200.0	1.63E-03
300.0	3.26E-03
500.0	3.26E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.29
8P	34.4	0.84
12P	51.6	0.20
4T	79.2	0.21
HSS	348.0	0.60

HSS High Speed Shaft

Broadband Info

Grms (Grms)	1.10
Max Vel (in/sec)	3.72
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	1.49
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

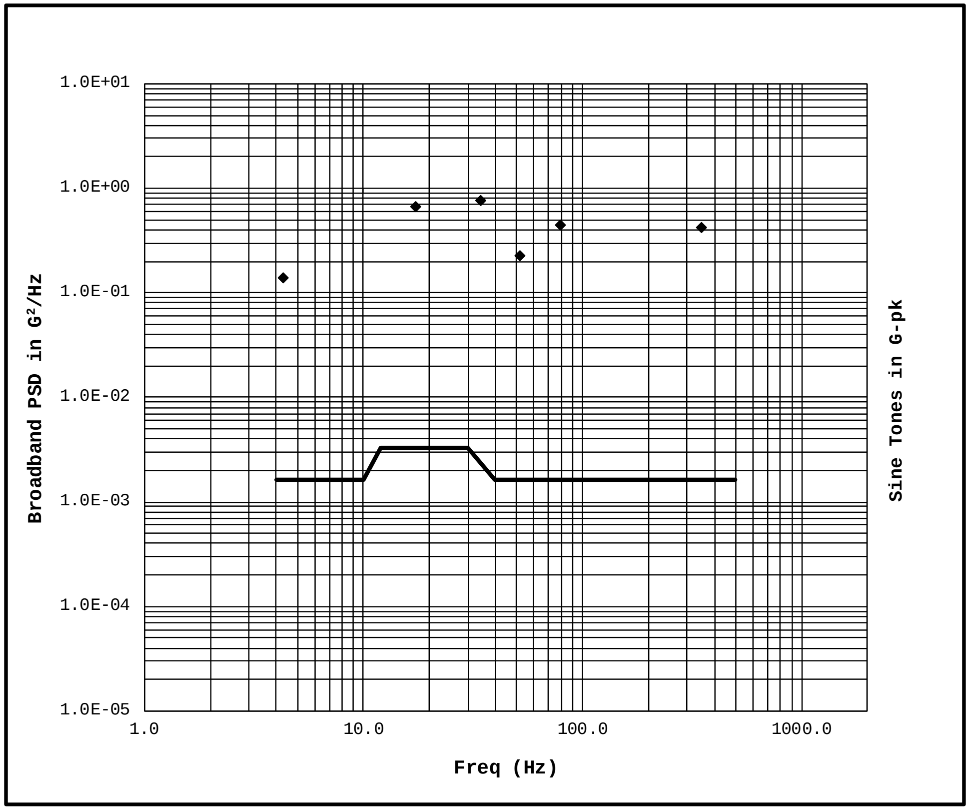
Figure D-11. UH-60M LVTS, Region: General; Axis: Transverse.

UH-60M LVTS

Aircraft Region: General

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
10.0	1.63E-03
12.0	3.26E-03
30.0	3.26E-03
40.0	1.63E-03
500.0	1.63E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.14
4P	17.2	0.68
8P	34.4	0.77
12P	51.6	0.23
4T	79.2	0.44
HSS	348.0	0.42

HSS High Speed Shaft

Broadband Info

Grms (Grms)	0.92
Max Vel (in/sec)	4.14
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	2.41
Max Disp (in Pk-Pk)	0.15

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

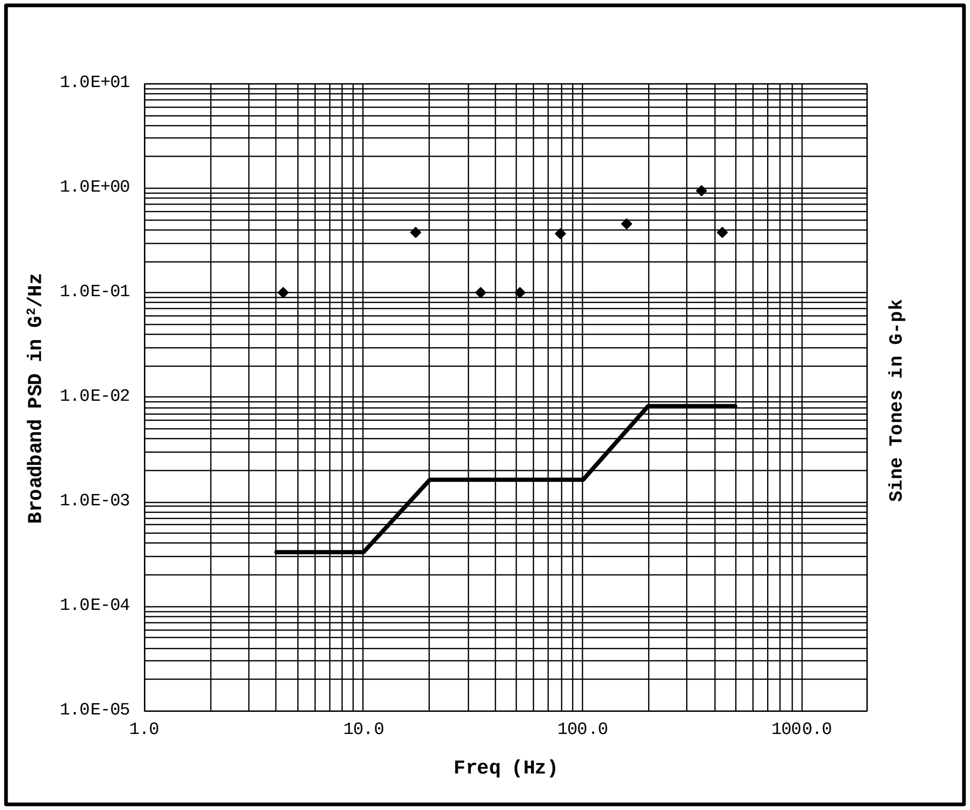
Figure D-12. UH-60M LVTS, Region: General; Axis: Vertical

UH-60M LVTS

Aircraft Region: Transition Section

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-04
10.0	3.26E-04
20.0	1.63E-03
100.0	1.63E-03
200.0	8.15E-03
500.0	8.15E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.37
8P	34.4	0.10
12P	51.6	0.10
4T	79.2	0.37
8T	158.4	0.46
HSS	348.0	0.94
MGBx2	436.0	0.37

HSS: High Speed Shaft
MGBx2: Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	1.74
Max Vel (in/sec)	2.57
Max Disp (In Pk-Pk)	0.08

Sine Tone Info

Max Vel (in/sec)	1.43
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

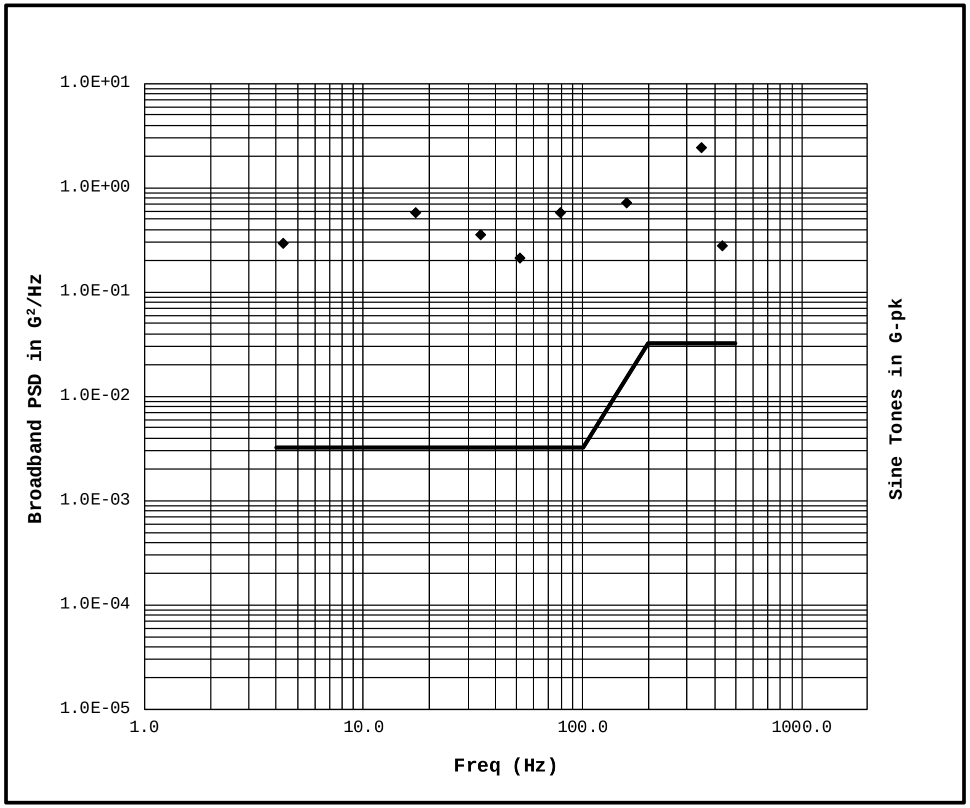
Figure D-13. UH-60M LVTS, Region: Avionics Bay; Axis: Long.

UH-60M LVTS

Aircraft Region: Transition Section

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-03
100.0	3.26E-03
200.0	3.26E-02
500.0	3.26E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.29
4P	17.2	0.59
8P	34.4	0.35
12P	51.6	0.21
4T	79.2	0.57
8T	158.4	0.73
HSS	348.0	2.43
MGBx2	436.0	0.28

HSS: High Speed Shaft
MGBx2 Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	3.40
Max Vel (in/sec)	5.64
Max Disp (In Pk-Pk)	0.24

Sine Tone Info

Max Vel (in/sec)	4.19
Max Disp (in Pk-Pk)	0.31

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

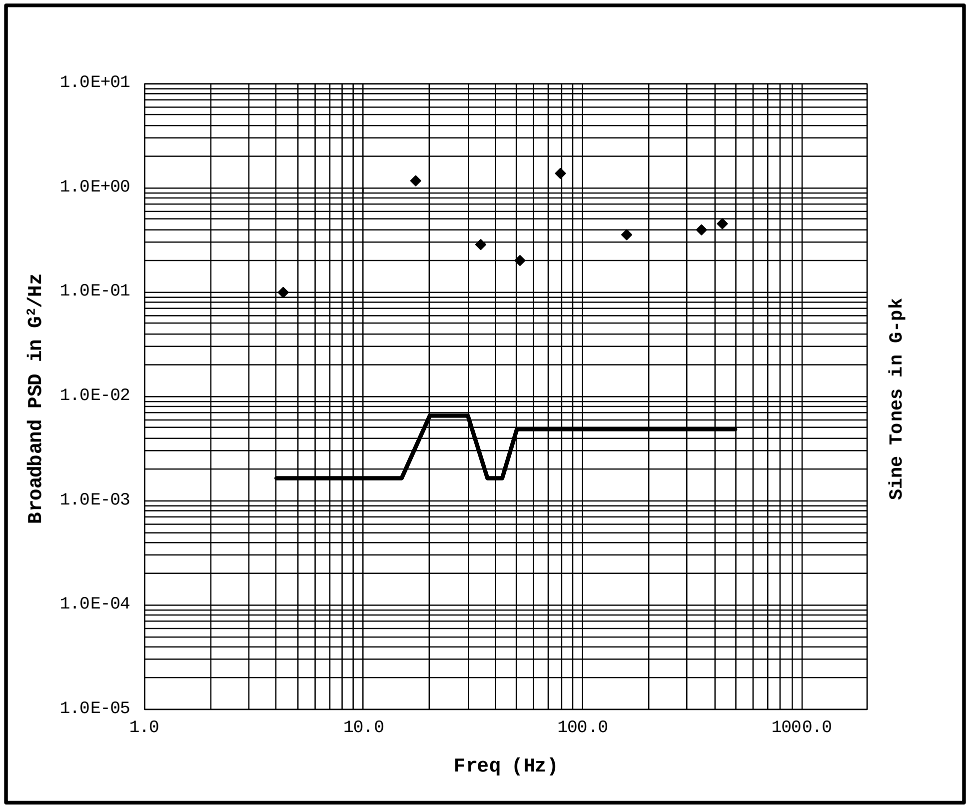
Figure D-14. UH-60M LVTS, Region: Avionics Bay; Axis: Transverse.

UH-60M LVTS

Aircraft Region: Transition Section

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
15.0	1.63E-03
20.0	6.52E-03
30.0	6.52E-03
37.0	1.63E-03
43.0	1.63E-03
50.0	4.89E-03
500.0	4.89E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	1.18
8P	34.4	0.28
12P	51.6	0.20
4T	79.2	1.36
8T	158.4	0.36
HSS	348.0	0.40
MGBx2	436.0	0.46

HSS: High Speed Shaft
MGBx1: Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	1.54
Max Vel (in/sec)	4.48
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	4.22
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

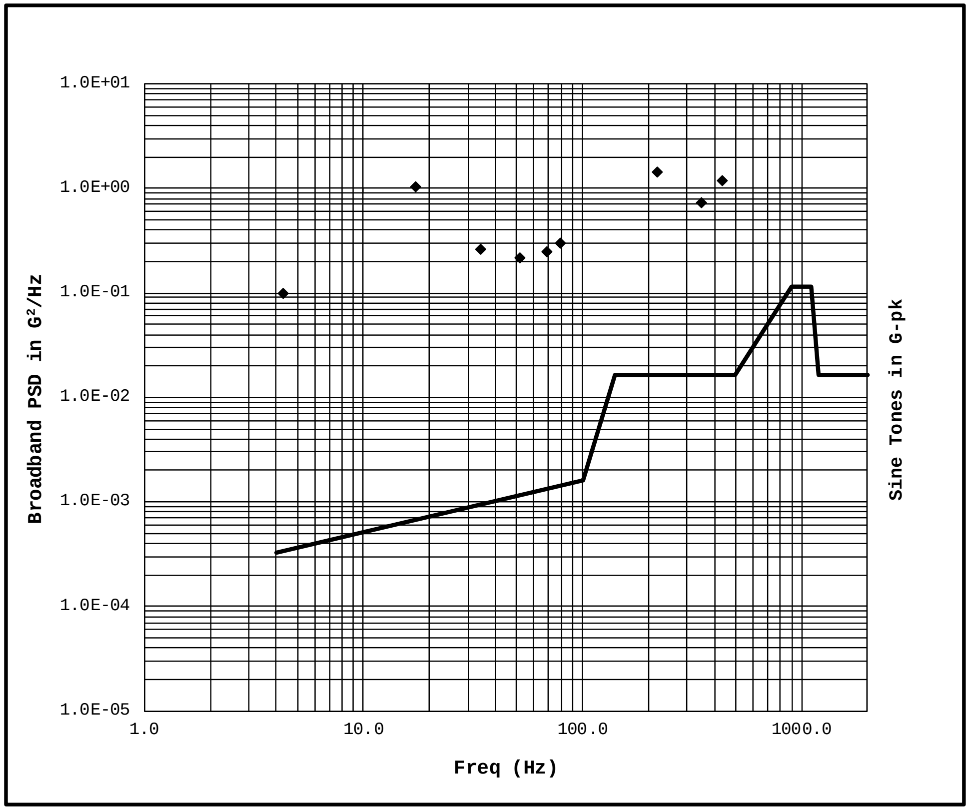
Figure D-15. UH-60M LVTS, Region: Avionics Bay; Axis: Vertical.

UH-60M LVTS

Aircraft Region: Main Transmission

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-04
100.0	1.63E-03
140.0	1.63E-02
500.0	1.63E-02
900.0	1.14E-01
1100.0	1.14E-01
1200.0	1.63E-02
2000.0	1.63E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	1.04
8P	34.4	0.26
12P	51.6	0.22
16P	68.8	0.25
4T	79.2	0.30
MGBx1	218	1.44
HSS	348	0.73
MGBx2	436	1.19

MGBx1: Main Gearbox Lube Pump
MGBx2: **MGB Lube Pump Harmonic**
HSS: **High Speed Shaft**

Broadband Info

Grms (Grms)	8.31
Max Vel (in/sec)	3.22
Max Disp (In Pk-Pk)	0.08

Sine Tone Info

Max Vel (in/sec)	3.72
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

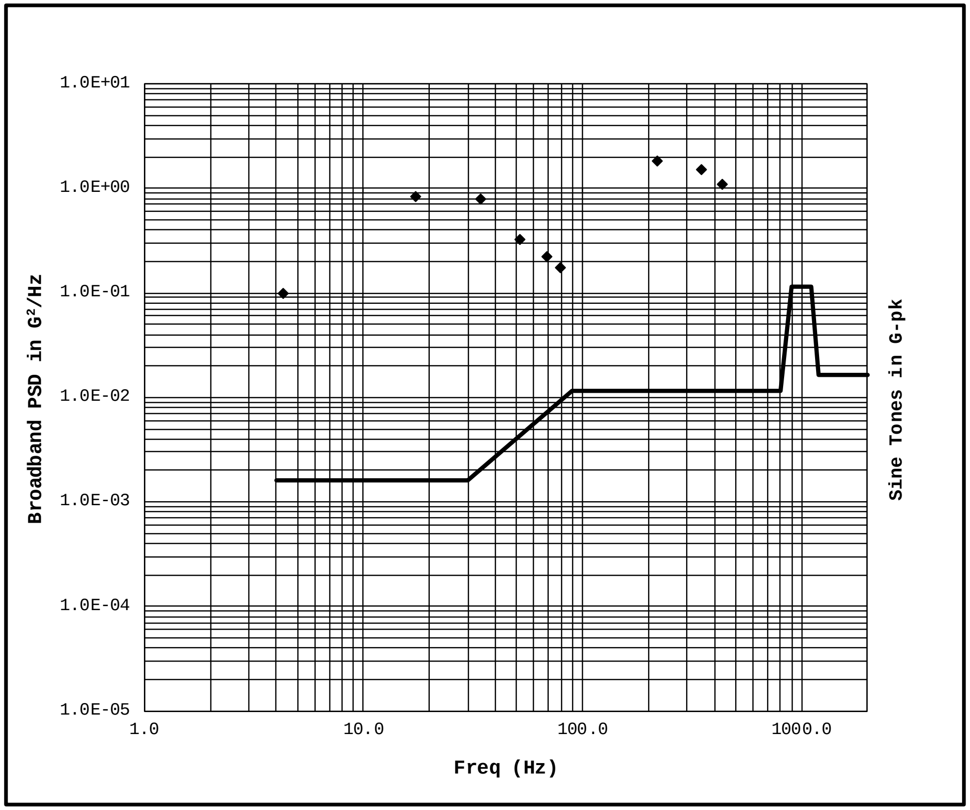
Figure D-16. UH-60M LVTS, Region: Main Transmission; Axis: Long.

UH-60M LVTS

Aircraft Region: Main Transmission

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
30.0	1.63E-03
90.0	1.14E-02
800.0	1.14E-02
900.0	1.14E-01
1100.0	1.14E-01
1200.0	1.63E-02
2000.0	1.63E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.84
8P	34.4	0.79
12P	51.6	0.33
16P	68.8	0.22
4T	79.2	0.17
MGBx1	218.0	1.84
HSS	348.0	1.51
MGBx2	437.0	1.08

MGBx1: Main Gearbox Lube Pump
MGBx2: **MGB Lube Pump Harmonic**
HSS: **High Speed Shaft**

Broadband Info

Grms (Grms)	7.34
Max Vel (in/sec)	4.51
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	3.00
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-17. UH-60M LVTS, Region: Main Transmission; Axis: Transverse.

UH-60M LVTS

Aircraft: Main Transmission

Axis: Vertical

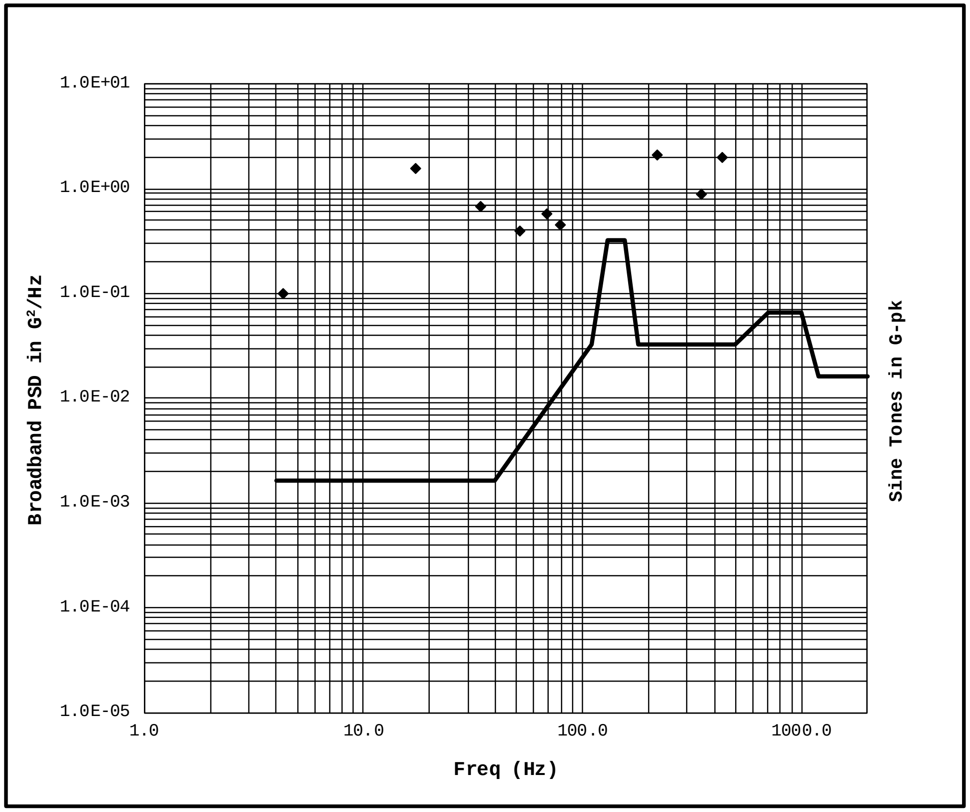
Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
40.0	1.63E-03
110.0	3.26E-02
130.0	3.26E-01
155.0	3.26E-01
180.0	3.26E-02
500.0	3.26E-02
700.0	6.52E-02
1000.0	6.52E-02
1200.0	1.63E-02
2000.0	1.63E-02

Broadband Info

Grms (Grms) 8.62

Max Vel (in/sec) 6.83

Max Disp (In Pk-Pk) 0.17



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	1.55
8P	34.4	0.68
12P	51.6	0.40
16P	68.8	0.57
4T	79.2	0.46
MGBx1	218.0	2.08
HSS	348.0	0.88
MGBx2	437.0	1.97

MGBx1: Main Gearbox Lube Pump
MGBx2: **MGB Lube Pump Harmonic**
HSS: **High Speed Shaft**

Sine Tone Info

Max Vel (in/sec) 5.53

Max Disp (in Pk-Pk) 0.11

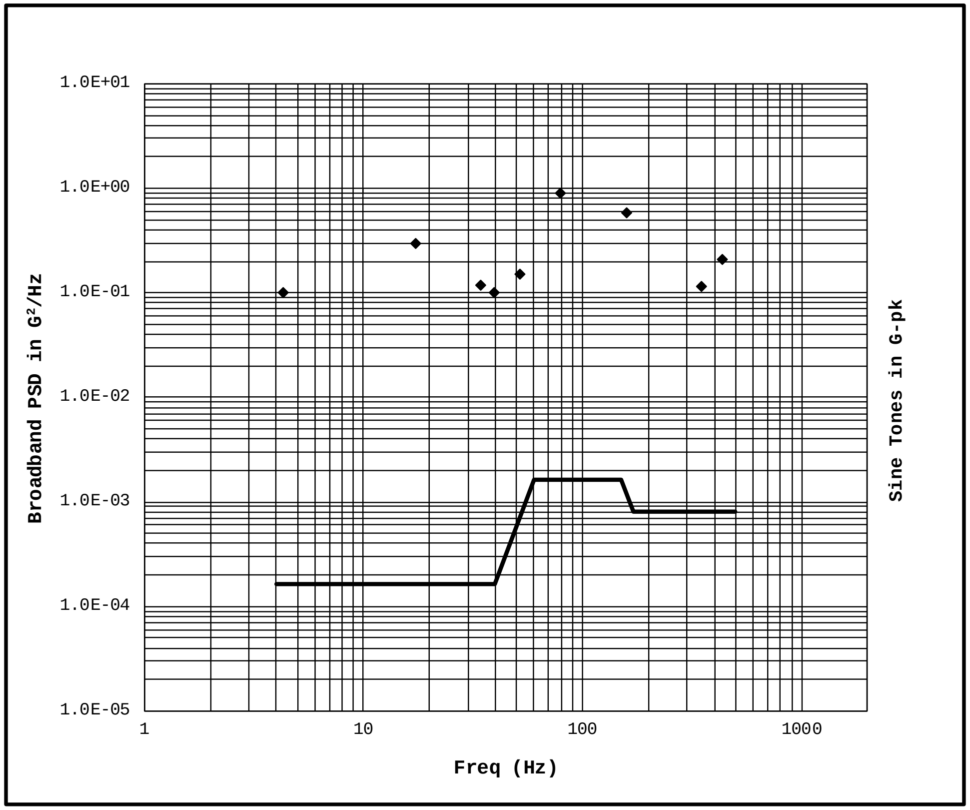
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-18. UH-60M LVTS, Region: Main Transmission; Axis: Vertical.

UH-60M LVTS
Aircraft Region: Tail Cone
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4	1.63E-04
40	1.63E-04
60	1.63E-03
150	1.63E-03
170	8.15E-04
500	8.15E-04



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.29
8P	34.4	0.12
2T	39.6	0.10
12P	51.6	0.15
4T	79.2	0.89
8T	158	0.58
HSS	348	0.12
MGBx2	436	0.21

HSS: High Speed Shaft
MGBx2: Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	0.68
Max Vel (in/sec)	1.45
Max Disp (In Pk-Pk)	0.05

Sine Tone Info

Max Vel (in/sec)	1.43
Max Disp (in Pk-Pk)	0.11

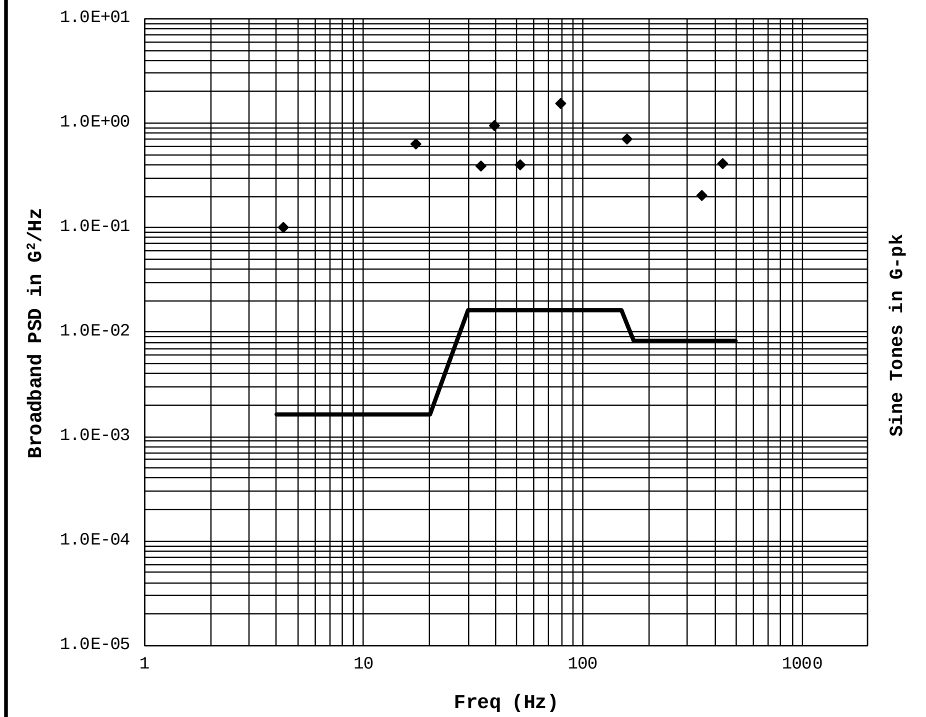
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-19. UH-60M LVTS, Region: Tail Cone; Axis: Long.

UH-60M LVTS
Aircraft Region: Tail Cone
Axis: Transverse

Broadband - PSD	
Freq(Hz)	G^2/Hz
4	1.63E-03
20	1.63E-03
30	1.63E-02
150	1.63E-02
170	8.15E-03
500	8.15E-03



Sine Tones - G-Peak		
Tone	Freq(Hz)	G-Pk
1P	4.3	0.10
4P	17.2	0.63
8P	34.4	0.39
2T	39.6	0.95
12P	51.6	0.40
4T	79.2	1.52
8T	158	0.70
HSS	348	0.20
MGBx2	436	0.41

HSS: High Speed Shaft
MGBx2: Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	2.23
Max Vel (in/sec)	5.53
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	2.26
Max Disp (in Pk-Pk)	0.11

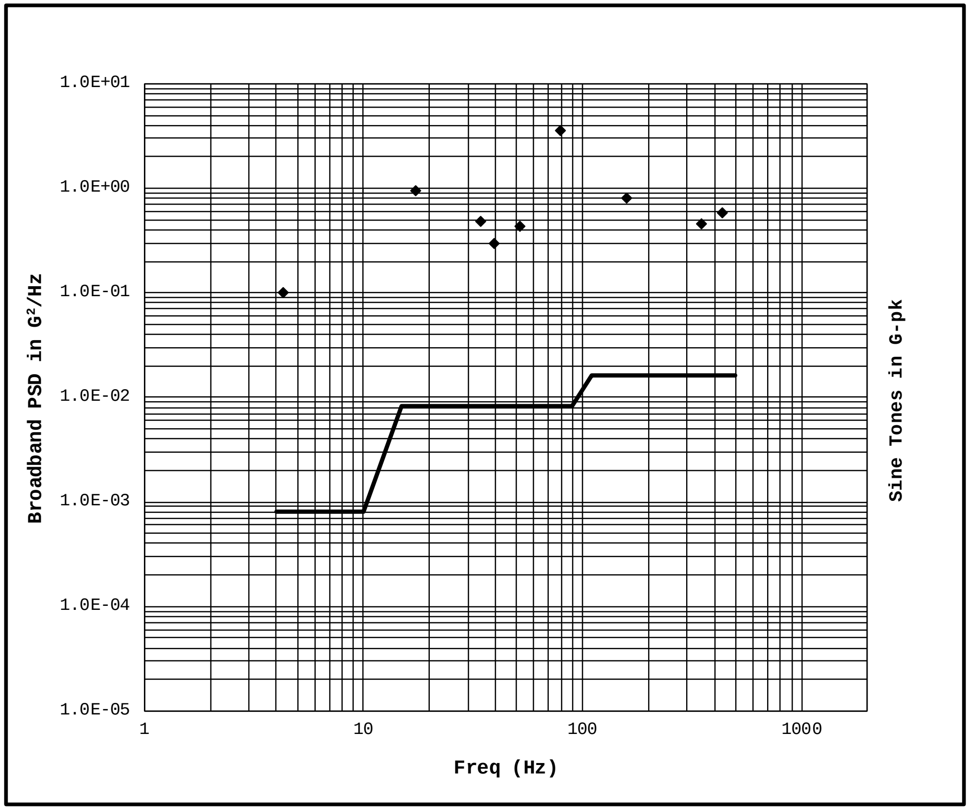
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-20. UH-60M LVTS, Region: Tail Cone; Axis: Transverse.

UH-60M LVTS
Aircraft Region: Tail Cone
Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4	8.15E-04
10	8.15E-04
15	8.15E-03
90	8.15E-03
110	1.63E-02
500	1.63E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.10
4P	17.2	0.95
8P	34.4	0.48
2T	39.6	0.29
12P	51.6	0.44
4T	79.2	3.58
8T	158	0.82
HSS	348	0.46
MGBx2	436	0.58

HSS: High Speed Shaft
MGBx1: Main Gearbox Lube Pump Harmonic

Broadband Info

Grms (Grms)	2.69
Max Vel (in/sec)	5.25
Max Disp (In Pk-Pk)	0.14

Sine Tone Info

Max Vel (in/sec)	3.38
Max Disp (in Pk-Pk)	0.11

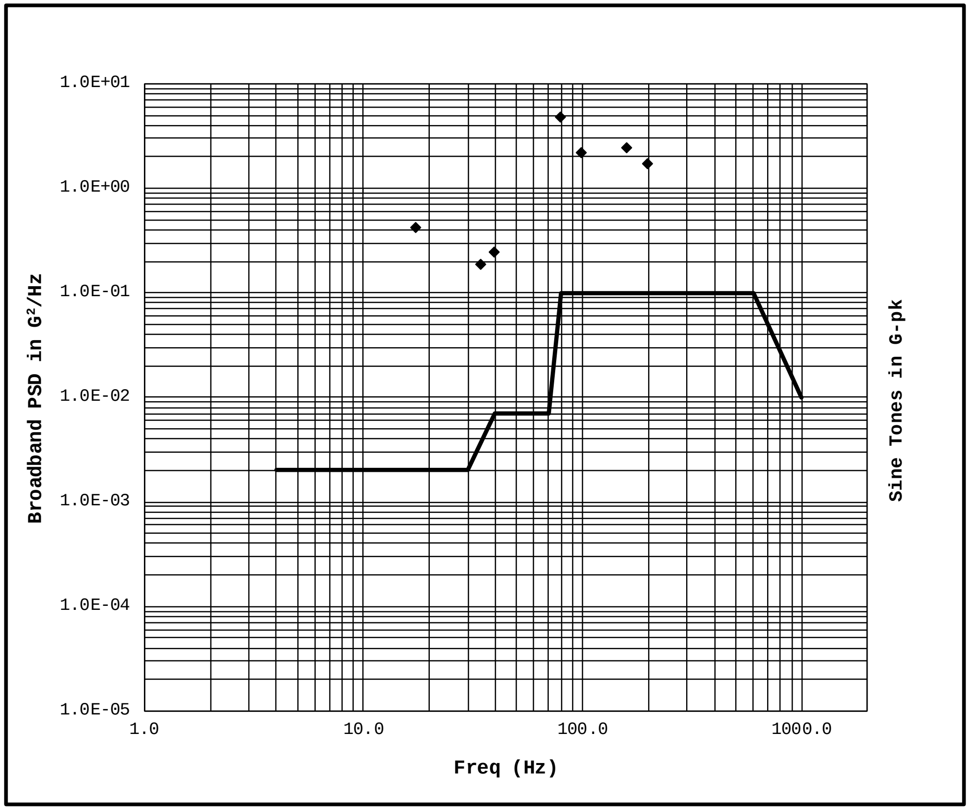
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-21. UH-60M LVTS, Region: Tail Cone; Axis: Vertical.

UH-60M LVTS
Aircraft Region: Vertical Tail Pylon
Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	2.00E-03
30.0	2.00E-03
40.0	7.00E-03
70.0	7.00E-03
80.0	1.00E-01
600.0	1.00E-01
1000.0	1.00E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
4P	17.2	0.42
8P	34.4	0.19
2T	39.6	0.24
4T	79.2	4.82
5T	99.0	2.18
8T	158.4	2.44
10T	198.0	1.71

Broadband Info

Grms (Grms)	8.18
Max Vel (in/sec)	7.63
Max Disp (In Pk-Pk)	0.19

Sine Tone Info

Max Vel (in/sec)	3.73
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

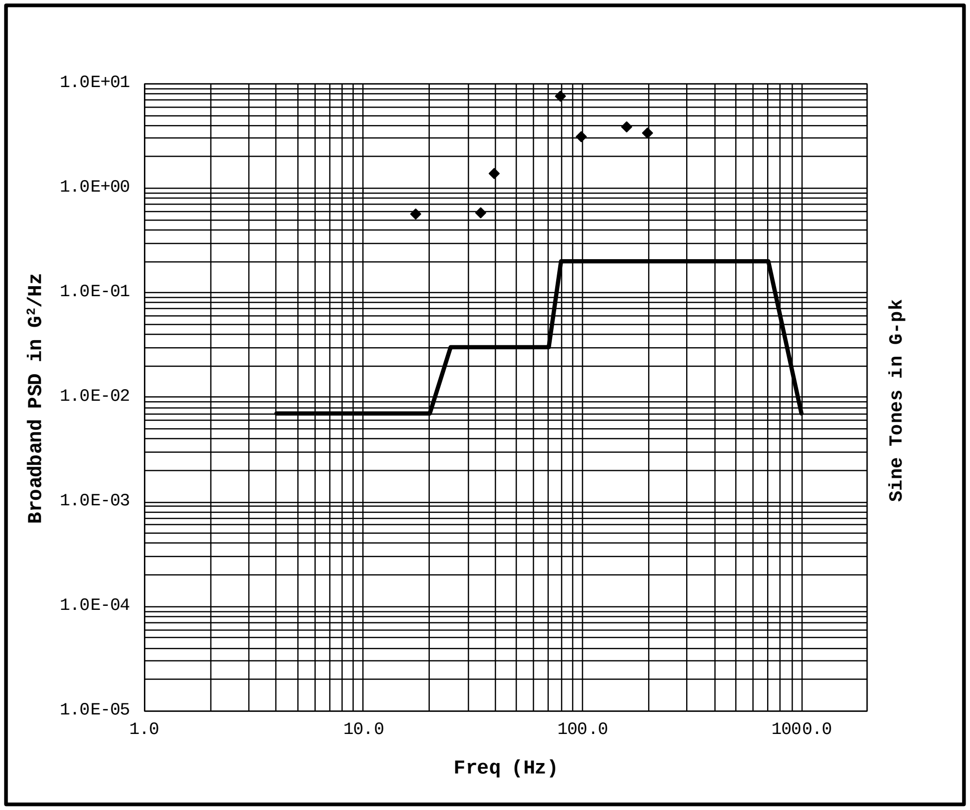
Figure D-22. UH-60M LVTS, Region: Tail Rotor; Axis: Long.

UH-60M LVTS

Aircraft Region: Vertical Tail Pylon

Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	7.00E-03
20.0	7.00E-03
25.0	3.00E-02
70.0	3.00E-02
80.0	2.00E-01
700.0	2.00E-01
1000.0	7.00E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
4P	17.2	0.57
8P	34.4	0.58
2T	39.6	1.39
4T	79.2	7.64
5T	99.0	3.08
8T	158.4	3.83
10T	198.0	3.39

Broadband Info

Grms (Grms)	11.93
Max Vel (in/sec)	12.67
Max Disp (In Pk-Pk)	0.36

Sine Tone Info

Max Vel (in/sec)	5.92
Max Disp (in Pk-Pk)	0.18

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

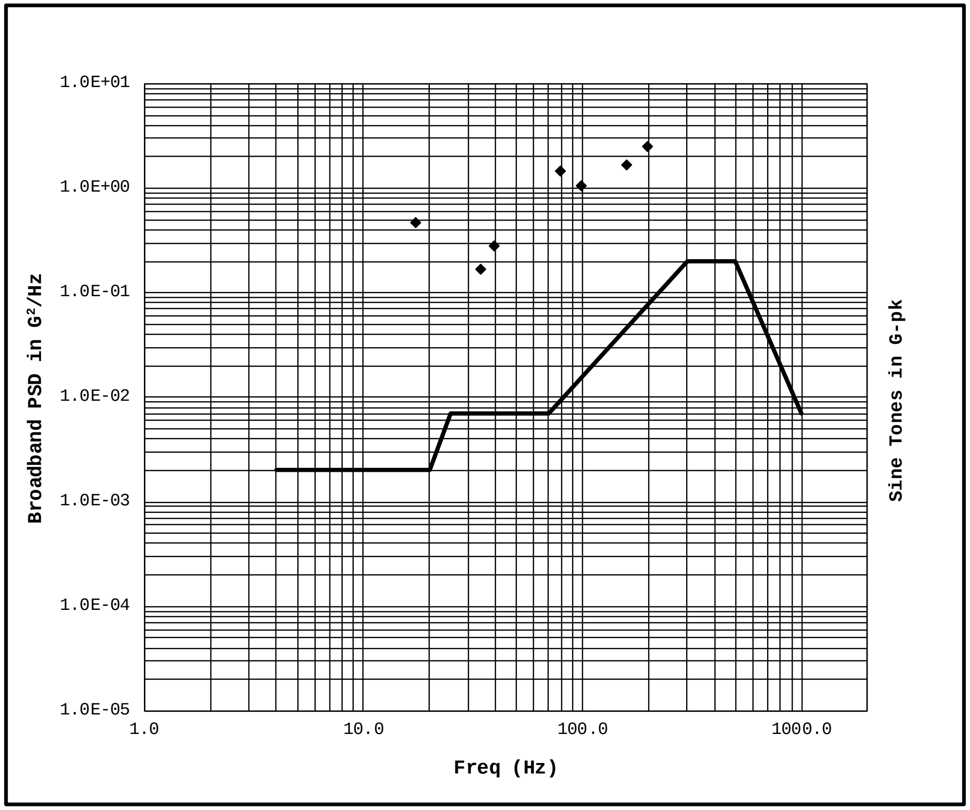
Figure D-23. UH-60M LVTS, Region: Tail Rotor; Axis: Transverse.

UH-60M LVTS

Aircraft Region: Vertical Tail Pylon

Axis: Vertical

Broadband - PSD	
Freq(Hz)	G^2/Hz
4.0	2.00E-03
20.0	2.00E-03
25.0	7.00E-03
70.0	7.00E-03
300.0	2.00E-01
500.0	2.00E-01
1000.0	7.00E-03



Sine Tones - G-Peak		
Tone	Freq(Hz)	G-Pk
4P	17.2	0.47
8P	34.4	0.17
2T	39.6	0.28
4T	79.2	1.45
5T	99.0	1.05
8T	158.4	1.67
10T	198.0	2.48

Broadband Info

Grms (Grms)	9.09
Max Vel (in/sec)	6.86
Max Disp (In Pk-Pk)	0.19

Sine Tone Info

Max Vel (in/sec)	1.68
Max Disp (in Pk-Pk)	0.11

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

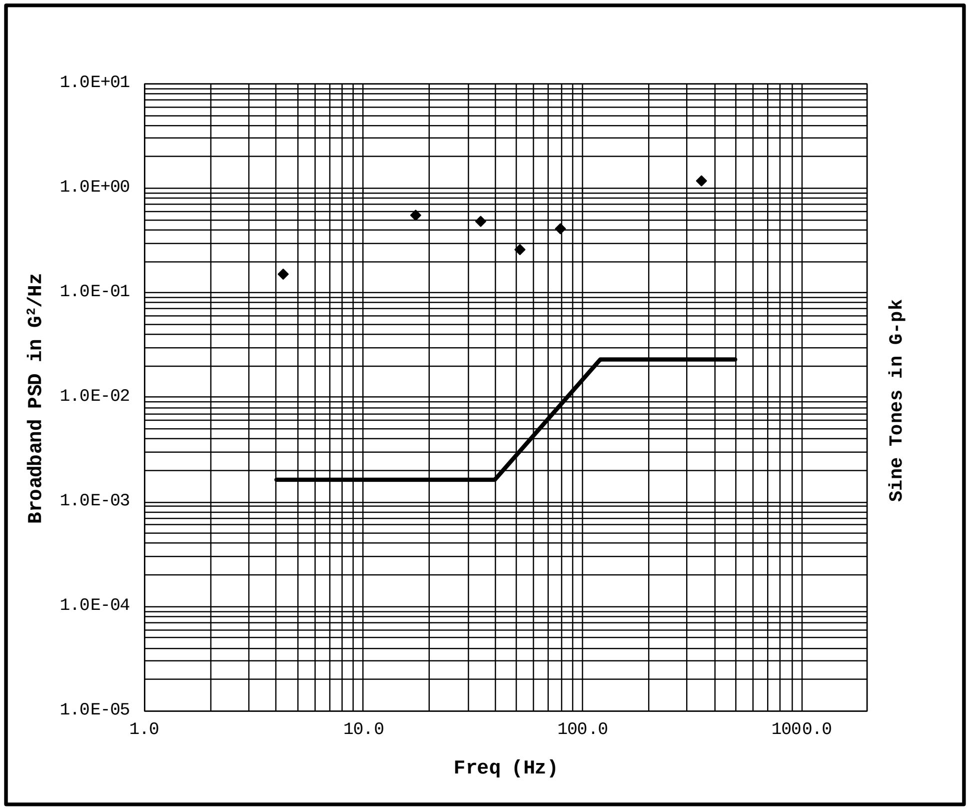
Figure D-24. UH-60M LVTS, Region: Tail Rotor; Axis: Vertical.

UH-60M LVTS

Aircraft Region: External Store

Axis: Long

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	1.63E-03
40.0	1.63E-03
120.0	2.28E-02
500.0	2.28E-02



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.15
4P	17.2	0.56
8P	34.4	0.48
12P	51.6	0.26
4T	79.2	0.41
HSS	348.0	1.17

HSS: High Speed Shaft

Broadband Info

Grms (Grms)	3.08
Max Vel (in/sec)	4.58
Max Disp (In Pk-Pk)	0.17

Sine Tone Info

Max Vel (in/sec)	2.14
Max Disp (in Pk-Pk)	0.16

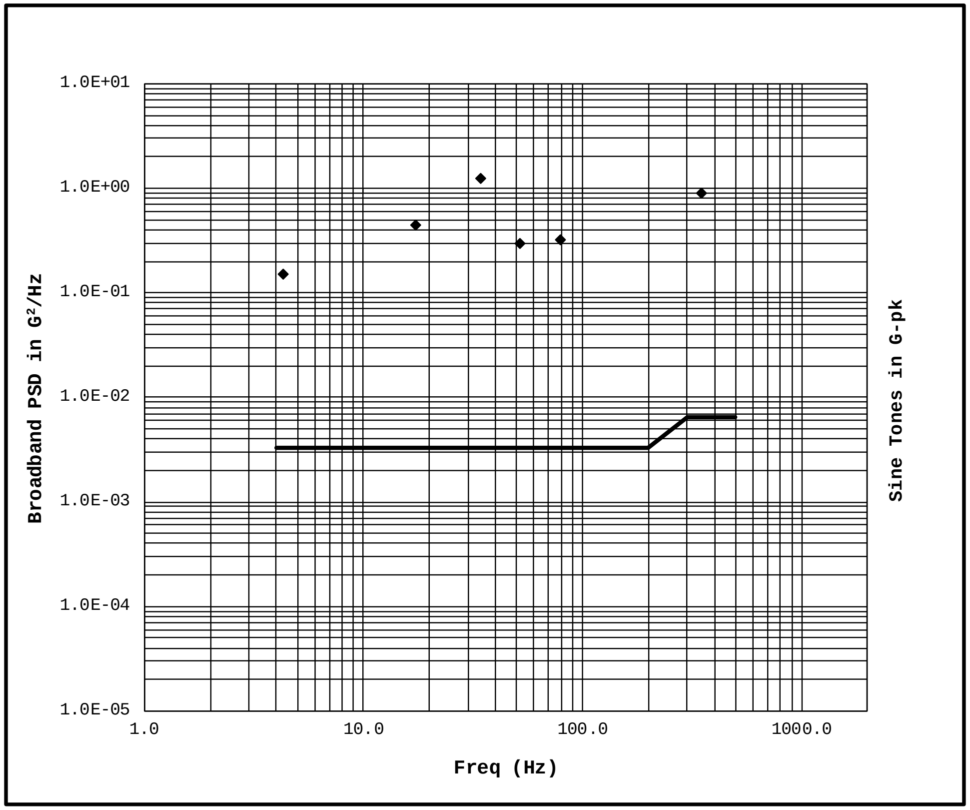
Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-25. UH-60M LVTS, Region: External Stores; Axis: Long.

UH-60M LVTS
Aircraft Region: External Store
Axis: Transverse

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-03
200.0	3.26E-03
300.0	6.52E-03
500.0	6.52E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.15
4P	17.2	0.44
8P	34.4	1.25
12P	51.6	0.30
4T	79.2	0.32
HSS	348.0	0.90

HSS: High Speed Shaft

Broadband Info

Grms (Grms)	1.56
Max Vel (in/sec)	5.26
Max Disp (In Pk-Pk)	0.24

Sine Tone Info

Max Vel (in/sec)	2.24
Max Disp (in Pk-Pk)	0.16

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

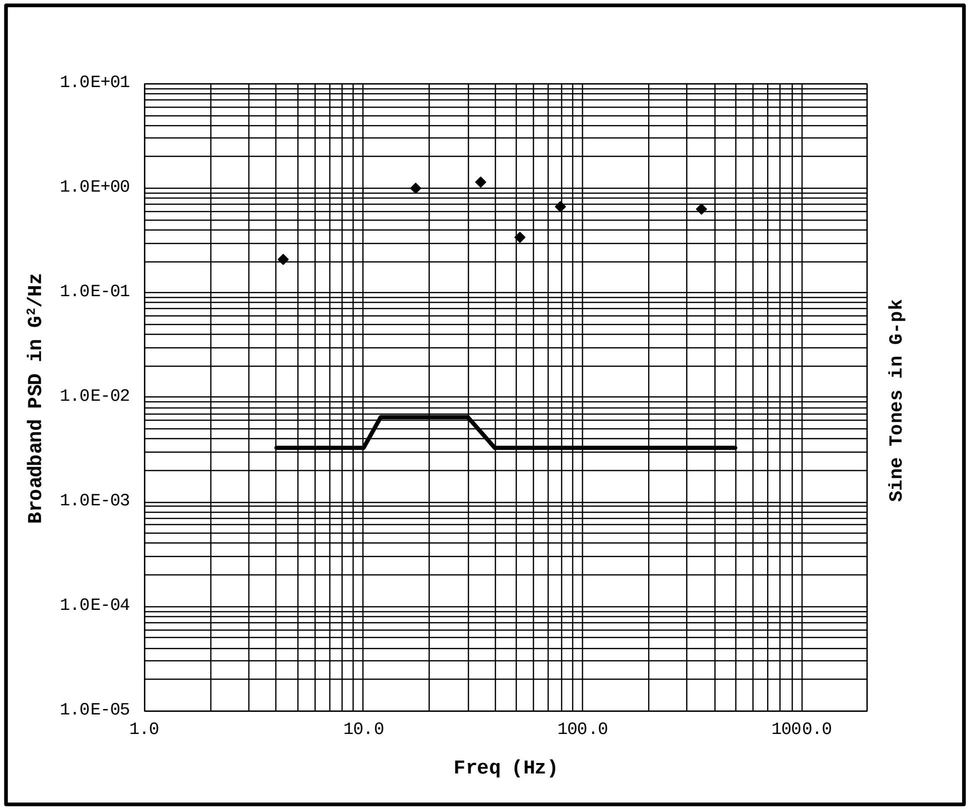
Figure D-26. UH-60M LVTS, Region: External Stores; Axis: Transverse.

UH-60M LVTS

Aircraft Region: External Store

Axis: Vertical

Broadband - PSD	
Freq(Hz)	**G^2/Hz**
4.0	3.26E-03
10.0	3.26E-03
12.0	6.52E-03
30.0	6.52E-03
40.0	3.26E-03
500.0	3.26E-03



Sine Tones - G-Peak		
Tone	**Freq(Hz)**	**G-Pk**
1P	4.3	0.21
4P	17.2	1.01
8P	34.4	1.16
12P	51.6	0.34
4T	79.2	0.66
HSS	348.0	0.63

HSS: High Speed Shaft

Broadband Info

Grms (Grms)	1.30
Max Vel (in/sec)	5.85
Max Disp (In Pk-Pk)	0.25

Sine Tone Info

Max Vel (in/sec)	3.62
Max Disp (in Pk-Pk)	0.22

Duration: 4 Hours
Flight Time Represented: 2500 Flight Hours

Control Tolerance: In accordance with MIL-STD-810G, Method 514.6, Section 4.2.2

Figure D-27. UH-60M LVTS, Region: External Stores; Axis: Vertical.

APPENDIX E. REFERENCES.

1. MIL-STD-810G-CN1, Department of Defense Test Method Standard, Environmental Engineering Considerations and Laboratory Tests, 15 April 2014.

2. AECTP 240 Mechanical Conditions, Leaflet 2410/1 Development of Laboratory Vibration Test Schedules, Edition 3, June 2009.

3. Boeing Document Number D125-10011-1, CH-47 Block II Airframe Component Improvement Program (ACIP) Aircraft Usage Spectrum, 2 April 2014.

4. CSTE-DTC-AC-FT-I (70-10r2) MEMORANDUM, SUBJECT: Test Plan, UH-60 Dual Common Missile Warning System Software Test Bed Fiscal Year 2006, ATEC Project No. 2007-DT-ATTC-CMWSR-D2732.

5. AVNS-PRF-10002H, Performance Specification System Specification for the UH-60M Black Hawk Utility Helicopter, 3 March 2009.

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APPENDIX F. APPROVAL AUTHORITY.

CSTE-TM 12 June 2017

MEMORANDUM FOR

Commanders, All Test Centers
Technical Directors, All Test Centers
Directors, U.S. Army Evaluation Center
Commander, U.S. Army Operational Test Command

SUBJECT: Test Operations Procedure (TOP) 01-2-603 Rotorcraft Laboratory Vibration Test Schedules, Approved for Publication

1. TOP 01-2-603 Rotorcraft Laboratory Vibration Test Schedules, has been reviewed by the U.S. Army Test and Evaluation Command (ATEC) Test Centers, the U.S. Army Operational Test Command, and the U.S. Army Evaluation Center. All comments received during the formal coordination period have been adjudicated by the preparing agency. The scope of the document is as follows:

This TOP provides Laboratory Vibration Test Schedules (LVTS) for selected rotary wing aircraft. The LVTS presented in this TOP were developed from field measured data collected on the selected rotary wing platforms. The LVTS are designed to allow for the exposure of a test article to a flight vibration environment of a given rotary wing platform in a laboratory setting.

2. This document is approved for publication and will be posted to the Reference Library of the ATEC Vision Digital Library System (VDLS). The VDLS website can be accessed at https://vdls.atc.army.mil/.

3. Comments, suggestions, or questions on this document should be addressed to U.S. Army Test and Evaluation Command (CSTE-TM), 2202 Aberdeen Boulevard-Third Floor, Aberdeen Proving Ground, MD 21005-5001; or e-mailed to usarmy.apg.atec.mbx.atec-standards@mail.mil.

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Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Policy and Standardization Division (CSTE-TM), U.S. Army Test and Evaluation Command, 2202 Aberdeen Boulevard, Aberdeen Proving Ground, Maryland 21005-5001. Technical information may be obtained from the preparing activity: Environmental Test Division (TEDT-RT-ECD), Redstone Test Center, Redstone Arsenal, Alabama, 35898-8052. Additional copies can be requested through the following website: http://www.atec.army.mil/publications/topsindex.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.